INDEX

A

Access control
  definition, 897–898
  delegation, 898–899
  management, 898
  policy, 899
  role based, 899
  structure, 898
  substation, 900–901
Access control lists (ACL)
  commands, 513
  Linux permission system, 513
Access control protocol
  DIAMETER, 569
  LDAP, 569
  RADIUS, 569
  TAKACS, 569
Access control system (ACS)
  substation automation, 900–901
  user validation policies, 569
Access protection
  models, 565–568
  network, 568–570
Access protection architecture
  generic network
    ACS, 569
    network access controller, 568–569
  NAP in VISTA, 569–570
Access protection models
  Bell Padula, 565–566
  capabilities, 566–567
  control lists, 566
  resource and users, 565
Access schemes
  CDM, 529, 530
  TDM, 530
  WDM, 529–530
Accuracy
  data reconciliation, 376
  key variables, 73, 74
Accuracy constrained networks, 81
ACL, *see* Access control lists
ACM Code, *see* Association of Computing Machinery Code
ACN, *see* Area control network
Acousto-optic (AO), 537
Active filter
  bilinear transfer function, 323
  IC, 323
  RC filters, 322
Actuator–sensor interface (AS-i), 60, 582
  communication profile, 665
  data link, 665
  description, 664
  execution control
    cyclic data transfer, 666, 667
    function, 665
    initialization phase, 666
    operational phases, 666
  physical, 665
A/D and D/A converters, 325, 330–335
Adaptive capability of MFA, 419
Adaptive control, *see* MFA control software
Adaptive-network-based fuzzy inference systems (ANFIS), 846
ADC, *see* Analog-to-digital converters
Add drop multiplexer
  optical, 547
  reconfigurable, 547
Adders and multipliers, 319
Address
  long, 594
  short, 594
Addressing
  logical, 650–651
  node, 650
  position, 650
Address Resolution Protocol (ARP), 490
ADSL, *see* Asymmetrical digital subscriber line
ADU, *see* Application data unit
Advanced control methods, 415, 424, 436
Advanced data preprocessing, 221
Advanced process control (APC), 415
Advanced regulatory control (ARC), 415, 416, 421
Advanced Research Projects Agency (ARPA), 484
Advanced Research Projects Agency Network (ARPANET), 275, 473, 484–486, 527
Advance encryption standard (AES), 507
AES, *see* Advance encryption standard
AH, *see* Authentication header
AI, *see* Artifical intelligence
Aims
  authentication, 674
  availability, 674
  confidentiality, 674
  integrity, 674
  nonrepudiation, 674
Alarm count
  and operator intervention count, 207
Alarm detection, 730, 731
Alarm log display, 111, 114
Alarm management
  alarm filtering, 27
  creation, 104, 106
  operator console, 27
  periodic alarm resynchronization, 27
Alarms
  alert state, 26
  filtering, 26
  like process and unlike process, 26
  management, 27
    guidelines, 455
    reports, 455, 456
  suppression, 26
  time stamp, 27
ALARP, *see* "As low as reasonably practical"
Alerts
  alert notifier, 26, 27
  alert processing, 26–27
  analog alert, 26
  discrete alert, 26
  update alert, 26
Algorithm
  definition, 303
  sensors and control signals, 308
  speed calculation, 305
  universal computing machine, 306
All-optical networks (AONs), 546, 548
  circuit switch, 529
  packet switch, 529
  topologies, 530–532
Alternative energy, 940–949
American National Standards Institute (ANSI), 12, 494
Amplification
  signal-to-noise ratio (SNR), 338
  temperature changes detection, 338

Amplifiers
  erbium doped, 540
  Raman filters, 540
  semiconductor, 540–541
Amplitude modulation (AM), 320, 321
AMR, *see* Automated meter reading
A/M switch, *see* Auto/manual switch
Analog leased lines, 287
Analog output, 336
Analog systems
  classification, 314
  excitation and response signal, 314
  instruments, 313, 314
Analog-to-digital (A/D) conversion, 342
Analog-to-digital (A/D) converters
  accuracy, 335
  characteristics, 335
  conversion process, 325, 334
  delta-sigma, 334–335
  errors, 335
  flash/parallel converter, 333
  input range, 335
  linearity, 335
  process signal conditioning, 327
  successive approximation, 334
Analogue filters
  active, 322–323
  capacitive, 321
  crystal, 321
  IC active
    MOSFET-C, 323
    SC, integrators and biquad, 323
  microwave, 321
  passive, 321, 322
  RLC filters, 322
  switched-capacitor (SC), 323, 324
Analogue signal, *see* Signal
Analogue signal processing
  adder op-amp circuit, 319
  amplifiers, 319
  circuit components, 318
  operational amplifiers, 318–319
  V/I and I/V converters, 320
Analogue transmission
  electric current, 342
  frequency modulated, 343
  4-20mA, 342–343
  pneumatic pressure, 342
Analysis
  hazard, 724–727
  methods
    encapsulation, 186–187
    object-oriented, 186
    structured, 186
  risk, 724–727
ANFIS, *see* Adaptive-network-based fuzzy inference systems
ANN, *see* Artificial neural networks
ANSI, *see* American National Standards Institute
Anti-aliasing filtering
  Nyquist frequency, 28–29
  sampling, 28
Anti-delay feedforward MFA controller, 421, 428, 429
Anti delay MFA
  LabVIEW, 428
  pH controller, 424, 425
AO, *see* Acousto-optic
AONs, *see* All-optical networks
APC, *see* Advanced process control
Aperiodic signal, 314
APOGEE® building automation system (BAS), 434
Application data unit (ADU), 638–639
Application layer
  client server, 602
  dynamic host conoeguration protocol (DHCP), 54
  publisher, 603
  report distribution, 603
  simple network management protocol (SNMP), 54
  simple network time protocol (SNTP), 54
  subscriber, 603
  wirelessHART, 65
Application level gateways, 500
Application of SEO
  cooking oven, 445
  energy saving, 445–447
  injection moulding, 447
  plastic forming-injection, 447
  power generation, 447–448
  procedure, 444
  public services electric and gas, 448
Application software
  configuration based, 361–362
  custom, 388
  data analysis and visualization, 362–363
  development, 360–361
  freeware, 388, 390
  open source, 388
  packaged, 388
  public domain, 388
  shareware, 388, 390
Application-specific computer
  definition, 303
  embedded system, 308–309
  miniaturization, 308
APSD, *see* Auto power spectral density
ARC, *see* Advanced regulatory control
Area control network (ACN), 33
ARMA model, *see* Autoregressive moving average model
AR model, *see* Autoregressive model
ARP, *see* Address Resolution Protocol
ARPA, *see* Advanced Research Projects Agency
Artifical intelligence (AI)
  backpropagation technique, 842–843
  BPNN
    ANN, 842
    regression analysis, 843
  fuzzy control, 843–845
  hydrocyclone, 840–841
  neural fuzzy systems, 845–846
  online control, hydrocyclones
    correct prediction, d50$_c$, 840–841
    signal processing, 841
  tromp curves, *d*50 and *d*50$_c$, 840
Artificial neural networks (ANN), 415–416, 418, 842–843, 845–846
  autoregressive model, 261
  biological neurotransmission process, 256
  nerve cell, 256–258
  optimization, 259
AS-i, *see* Actuator–sensor interface
"As low as reasonably practical" (ALARP), 724–725
ASM consortium, 731
Association of Computing Machinery (ACM) Code, 675
Asymmetrical digital subscriber line (ADSL), 288
Asynchronous traffic, 578, 581
Asynchronous transfer mode (ATM), 475, 557–558
Asynchronous transfer mode (ATM) Forum, 494
ATM, *see* Asynchronous transfer mode
Attacks
  detecting, 502
  minimising, 502
  responding, 503
  tools, 495–497
Attenuation, 294
Attributes of people
  cost, 700
  experience, 700
  influence, 700
  knowledge, 700
  time, 700
Auditing
  control rooms, 704–705
  functionality, 699
  goals, 698–699
  prerequisites, 698
  standards, 699–700
  upgrading networks, 705
Auditing functionality, 699
Auditing goals, 698–699
Auditing plants
  DCS, 698
  operation performance, 704–705
  prerequisites, 698–700
  staffing, 700–701
  types of audits, 702–704
  upgrade
    scope and migration method, 701–702
    types, 701
  upgrading networks, 705
Auditing staffing
  consultant, 700
  corporate engineer, 700
  engineering firm, 700
  plant engineer, 700
  vendor, 700
Auditing standards, 699–700
Audits, 879
Audit staff, 700–701
Authentication
  biometrics-based, 511–512
  certificate
    PKI, 511
    SSL handshake protocol, 511
  password
    challenge-response, 511

    - hacking, 510
    - salting and scratch list, 511
    - secure shell client, 511
  - token-based, 511
- Authentication header (AH), 521
- Authorization
  - access policies, 512
  - ACL, 513
  - advanced permissions
    - sticky bit, 513
    - SUID and SGID, 512–513
  - basic file permissions, 512
  - kernel capabilities and file attributes, 513
- Auto guided vehicle (AGV), 398–399
- Auto ignition temperature, 708–710
- Auto-managed networks, 523
- Auto/manual (A/M) switch, 421, 432
- Automate
  - cost and benefit, 162–163
  - feasibility, 162
  - intangible considerations, 162
  - job to automate, 162
  - selecting, 162
- Automated
  - monitoring, 728
  - testing filed devices, 728
- Automated meter reading (AMR), 860, 869
- Automatic control, 428, 429
- Automatic data logging, 360
- Automatic guided vehicles (AGVs), 811–812
- Automation
  - fixed, 159
  - flexible
    - FMS, 160
    - FWS, 160, 161
  - heating cycle
    - billet, 790
    - fuzzy logic, 795
    - hardware architecture, 791
    - phases, 793
    - primary globular structure, 781
    - pulses and pauses, 782
    - “READY” signal, 794
    - WinSit, 789
  - mechanical setup
    - handling unit, 794–795
    - transport container, 795
  - programmable, 159–160
  - reasons
    - flexibility, 159
    - labor costs, 158
    - productivity, 158
    - product quality, 159
    - safety, 159
  - robot
    - implementations, 161–164
    - industrial applications, 160–162
    - industrial programming and work-cell controls, 164–167
- Automation benefits, 801
- Automobile industry
  - organizational condition, 762–765
  - production
    - control, 773–776
    - planning, 765–773
  - reverse logistics and remanufacturing, 776–779
  - vehicle production, 762
- Automotive
  - industry, 809–810, 814–815
  - process, 809, 810
- Automotive industry
  - manufacturing, 814–815
  - PACS, 809–810
  - plant, 810–813
  - PLCS, 809–810
  - robotics and automation, 809
  - SCADA, 809–810
  - standards and code generation, 813–814
  - trends, 815–819
- Automotive plant
  - AGV, 811
  - assembly
    - body, 812
    - final, 813
  - engine
    - AGVs, 811–812
    - manufacturing process operations, 811
    - phases, 811
  - paint shop, 813
  - press work
    - automation aspects, 810
    - I/O, 811
    - MCS, 811
  - transmission, 811–812
  - vehicle manufacturing steps, 810
- Auto power spectral density (APSD)
  - frequency domain analysis, 911
  - neutron detector, 914, 915
- Autoregressive (AR) model, 260
- Autoregressive moving average (ARMA) model, 255, 260, 262
- Auxiliary screens, 111
- Availability, 738
- Availability, CAI, 571

B

- Back propagated neural network (BPNN), 842
- Backpropagation technique
  - ANN
    - data and predicted result, 842
    - data correlation, 843
    - Plitt’s model, 842
    - prediction error, 842–843
    - regression analysis, 843
    - statistical analysis, 842
  - BPNN
    - advantage, 842
    - limitations, 842
    - parameters selection, 842
- Balance of plant, 944
- Band-to-wavelength (BTW), 548, 549
- Batch
  - management software (BMS), 807
  - operations, 806–807
  - software, 807
  - standards, 807
- Batch automation
  - systems, 181–183
- Batch control function
  - discrete, 183
  - interlock, 183
  - sequential, 183–184
- Batch control models
  - control activity, 180
  - physical, 180
  - procedure, 180
- Batch control software, 172
- Batch control standards
  - benefits, 175–176
  - data structures, 173–174
  - guidelines, 173–174
  - languages, 173–174
  - models, 172–173
  - recipes, 174–175
  - records, 175
- Batch control systems
  - analysis methods
    - object-oriented, 186–187
    - structured, 186
  - applications
    - computer aided formulation, 188–189
    - EBR and signatures, 189–190
    - general and site recipes advantages, 188
    - KPIs, optimization, 192, 193
    - MPC, 190–191
    - product safety and traceability, 190
    - recipe update, product consistency, 191–192
    - US 21 CFR Part 11, 190
  - automation
    - DCS, 183
    - PAC, 182–183
    - PLC, 181–182
  - continuous processes, 172
  - fault tolerance and reliability
    - DCS, 197–198
    - requirements, 197
    - software error detection curve, 198
  - functions
    - discrete control, 183
    - interlock, 183
    - normal and exception logic, 184–185
    - regulatory control, 183
    - sequential control, 183–184
  - and management software, 172
  - models
    - control activity, 180
    - physical, 180
    - procedure, 180
  - process cell
    - classification, 181
    - definition, 180
    - plant physical structure, 181
  - project application specification (PAS)
    - acceptance criteria, 187–188
    - requirement, 187
    - system functional design, 187
  - selection criteria
    - application complexity, 198–199
    - supplier, 199
  - software and, 172
  - standards
    - benefits, 175–176
    - B2MML, 180

        control and enterprise integration, 178–179
        function block, 177–178
        general and site recipes, 174–175
        language data structures and guidelines, 173–174
        models and terminology, 172–173
        PLC programming language, 176–177
        production records, 175
    stimulating factors, 172
    supply chain optimization
        benefits, 196
        challenges, 196
        control and enterprise synchronization, 195–196
        enterprise wide, 194–195
        internet technology, 196–197
        levels, 193–194
        positioning, 192, 194
        process plant, 194
    unit and recipe management
        modes, 185
        phases, 185
        states, 185
Batch management software, 172
Batch process
    continuous, chilli, 18
    definition, 5
    liquid/solids level, 17
    manufacturing mode, 11
    pure, chilli, 17
Batch production records, 175
Batch profile
    profile control, 19–20
Batch terms and glossary
    control module, 176
    equipment, 176
    exception handling, 176
    process cells, 176
    process input, 176
    process output, 176
    unit, 176
Batteries, 924–927
    lithium ion, 924
    NiMH, 924–925
Battery charge controllers, 926
Battery costs, 925
Battery size codes, 924, 925
Bell Padula model, 565–566
Benchmarking
    categories and item, 749
    continuous reliability improvement, 748–749
    system rating scale, 749
Benefits, calibration, 142
Best practice
    alarms, 831
    animation, 830
    display, 830
    HMI, 829
    information, 830–831
Betz limit, 941
BGP, *see* Border Gateway Protocol
Bias detection
    challenging tasks, 370
    closure strategy, 370–371
    node selection, 371
    sample size, 373
    tests, 371–373
BIBO stable, *see* Bounded-input-bounded-output
Bidirectional electric meters, 921
Billet model
    data parameter extraction, 784–785
    design, 782–785
    development, 782–785
    notation, 782–783
    pseudolinear, 782
    system discretization, 783–784
Binary system
    definition, 303
    microprocessors, 304
Biological life cycle
    animal and plant life, 919
    energy, without carbon, 920
    photosynthesis and respiration, 920
    reversible fuel cells, 920
Black box, 417, 436
Block
    function (FB), 607–608
    resource, 607
    transducer, 608
Block check character (BCC)
    buffering and calculating, 289
    error detection, 287, 289
Blocks
    analog input, 630
    discrete input, 630
    function, 630
    output, 630
    physical, 630
    totalizer, 630
    transducer, 630
BOOTP, *see* Bootstrap Protocol
Bootstrap Protocol (BOOTP), 488
Border Gateway Protocol (BGP), 492
Bounded-input-bounded-output (BIBO) stable, 419
BPNN, *see* Back propagated neural network
Broadcasting communication, 466
BTW, *see* Band-to-wavelength
Budget
    craft labor, parts and vendor support costs, 752
    deferred maintenance identification, 752
    improvements, CMMS, 752
    life-cycle costing support, 752
    operating departments, 752
Buffer function
    manufacturing system simulation, 396
    stagnation, 395–396
Buffering
    feedback, 560
    feedforward, 560
    input, 560
    output, 559
    recirculation, 559–560
    shared, 559
Buses
    application, 933, 934, 936–937
    database, 936–937
    expansion buses, 352–353
    external buses, 353–355
    terminal (TB), 932, 933, 936–937
    topology, 351
    WinCC, 936–937
Business drivers, 37
Business performance
    monitoring hierarchy, 214
    process control
        benefits, 213–214
        objectives, 213
Business to business (B2B)
    supplier sites and multi-vendor, 197
    websites, 196
Business to manufacturing markup language standard (B2MML), 180
Bypass sequence
    operation, 114–115
    screens, HMI, 115–116, 124–129

C

Cache memory
    definition, 303
    L1 and L2, 307
    in microprocessors and microcontrollers, 307
CAD, *see* Computer-aided design
Calibrated risk graph method, 873
Calibration, 595–596
    benefits, 142
    chemical mixtures, 148
    cost
        certification, 145
        frequency, 146
    definitions, 141
    dynamic pressure, 149
    electronic, 146–147
    errors and uncertainties, 141–142
    factors, 143
    flow, 148
    institutions, 144
    internet
        iCals, 148
        traceability, 147
        VNA, 148
    laboratories, 144
    literature, 146
    management, 145
    MAP, *see* Measurement assurance planning
    personnel laboratories, 141, 143–144
    primary and secondary reference standard, 143
    procedure, 142–144
    provider, 141, 148
    records, 144
    remote and e-calibration, 147
    self-calibrations, 147
    sensor, 148
    set up, 142, 143, 145
    software support
        CMS, 145
        integration, CMMS, 145
        spreadsheets, 145
    spread sheets, 143, 145
    standards, 142, 143, 146–148
    static and dynamic, 143
    static pressure, 148–149

Calibration methods
  dynamic, 143, 147–149
  static, 143, 148, 149
Calibration procedure, 141, 143, 144
Calibration software, 144–145
Campus area networks (CANs), 345
Canonical representation
  Gauss–Jordan factorization, 366
  observable and unobservable variables, 366–367
  variable classification, 365–366
Capacitor
  SC filters, 323
  use, 318
Capacity factor, 942
Car production, 778
Carrier Ethernet, 561–563
Carrier sense multiple access (CSMA), 290
Cars
  electric, 921, 924–927, 929
  hybrid, 921, 925
Cause and effect diagrams, 102
CBA, *see* Component based automation
CBM, *see* Condition Based Monitoring
CBT, *see* Core-Based Tree
CC-Link, 349
CCM functions
  frequent start ups, 731
  large plants, 731
  unmanned operations, 731
  use, 731
CCM packages, 731, 732
CCN, *see* Complex communication networks
CDMA, *see* Code-division multiple access
Cellular telemetry
  CDMA, 296, 297, 299
  cells, definition, 295
  "cell site" and "base station", 295
  channels and clusters
    control, 295
    picocells, 296
    seven-cell, 295
  digital cellular data, 296–297
  FDMA, 296, 299
  GSM, 296, 297
  idealized *vs.* actual cell coverage, 295
  multiplexing, 296
  TDMA, 296, 297, 299
  topology, 297
CENELEC, *see* European Committee for Electrotechnical Standardization
Central processing unit (CPU)
  cache memory, 303, 307
  computer architecture, 306, 307
  microprocessors, 304
Centre for Operator Performance (COP), 38
CETs, *see* Core exit thermocouples
CGI, *see* Common Gateway Interface
Charge controllers, battery, 926
CIP, *see* Clean in place
CIP™, 349
Citect data historian
  industry standard protocols, 455
  production analysis, 455, 457
  reports generation, 455, 456
Classes II and III
  divisions, 709
  groups, 709–710
  ignitable mixtures, fibers, 709
  temperature rating, 710
  zones, 709
Class I
  division, 708
  groups, 708–709
  temperature rating, 709
  zones, 708
Classification
  discrete output values, 260
Classification of software, 385
Clean in place (CIP), 798
Client based VPN, 518
Client-server model
  vs. main frames/minicomputers, 476–477
  middleware, 477
  socket
    creation steps, 478
    defined, 477
    implementation issues, 477
    types, 477
Closed-loop, 415, 416
Closed loop tuning
  benefits, 247
  data, 247
  failures, 247–248
  testing, 245–247
  tools, 248–251
CMMS benefits
  budget accountability, 756
  improved work control, 755–756
  maintenance information level, 756
  MRO materials management, 756
  parts and materials, 756
  performance and service measurement, 756
  plan and schedule, 756
  PM/PdM, 756
  reliability analysis, 756
CMMS data integrity
  benchmark items, 749
  equipment history database, 750
  maintaining equipment database, 750–751
  materials bill, 750
  parts database, maintaining, 750
  PM/PdM database, 750
  spare parts database, 750
CMMS implementation
  budget and cost control, 752
  "Class A" installation, 749
  data integrity, 749–751
  education and training, 751
  maintenance performance measurement, 754–755
  materials management
    critical spares, 754
    electronic parts requisition, 753–754
    inventory, 753
    MRO, 753
    parts kiting, 753
    reorder notification process, 754
    warranty information, 754
  planning and scheduling, 752–753
  PM/PdM
    change process, 754
    compliance, 754
    lubrication services, 754
    reliability data, 754
    schedule, 754
    task descriptions, 754
  scheduling coordination, 753
  spare parts status, 753
  work control, 751–752
CMMS justification
  capabilities, 747
  elements, 748
  evaluation, 748
  maintenance excellence, case study, 748
CMMS management tool
  benchmarking, 748–749
  description, 746–747
  information technology, 747
  justification and selection, 747–748
  maintenance data and operation, 747
CMMS selection
  capabilities, 747
  elements, 747–748
  evaluation, 748
  maintenance excellence, case study, 748
CMMS training
  administrator, 751
  initial, 751
  ongoing, 751
  operations personnel, 751
Code-division multiple access (CDMA), 296, 297
Code generation
  compilation and codes, 104
  and standards, 813–814
Code of ethics, 675
Codes, battery size, 924, 925
Codifying, 330
Coefficient of power, 941
Collaborative MES, 696–697
Collector, hot water, 921
Collectors, PV
  grid connected system, 922–924
  optimization software, 924
  voltage deviation detection, 922
Collectors, solar, 920, 921, 926
  grid connected PV, 926
Combined intelligence
  methodology, 435
Combustion triangle
  fuel, 713
  ignition source, 713
  "inerting systems", 713
  oxidizer, 713
Commercial Off-The-Shelf (COTS) software, 495
Commissioning plan and forms, 102
Committees
  council, 153
  policy development, 153
  standing, 153
  technical management board, 153
Common Gateway Interface (CGI), 487
Common packet format (CPF), 643–644
Communication
  C band, 299
  Ka band, 299
  Ku band, 299

    L band, 299
    modes
        full duplex, 285
        half duplex, 285
        simplex, 284–285
Communication classes
    continuous, 646
    multiplexed, 646
Communication failure, 116
Communication hierarchy
    control network, 44
    factory, 44
    field, 44
    HMI, 44
Communication profile families (CPFs), 582
Communication speed, 594–595
Compensator, 420
Compensator gain, 430
Compilation and codes, 104
Complex communication networks (CCN), 523
Complex programmable logic device (CPLD)
    architecture, 310
    configuration bits, 311
    programmable interconnection matrix, 309
Component based automation (CBA)
    automation tasks, 632, 633
    bottling, 632
    plant architecture, 633
    PROFINET engineering tool, 632–633
Computer-aided design (CAD)
    drawings and instrumentation, 411
    models, 408
    package, 408
    system, 408
Computer aided formulation, 188–189
Computer architecture
    control system, 308
    CPU, memory and I/O, 306
    industry, 307–308
    information system, 308
    memory subsystem, 306–307
Computer control in mining
    design process, 848–850
    milling and processing, 850–854
    mineral processing, 847–848
    mines operation center, 854, 855
    RLG and test-bed surveying unit, 854
    software generated drift, 854
    teleremote operation
        benefits, 855
        chair, 854, 855
        evaluation, 855–856
Computerized maintenance
    description, 746
    implementation, 749–755
    justification, 747–748
    management systems, 746
    management tool, 746–749
    selection, 747–748
    training, 751
Computerized maintenance management system (CMMS)
    administrator, 751
    benefits, 755–756
    CBM, 746
    description, 746
    education and training, 751
    implementation, 749–755
    justification and selection, 747–748
    management tool, 746–749
    operations personnel, 751
    software packages, 746
    uses, 755
    web CMMS, 746
Computer networks
    classes
        LAN, 466–467
        MAN, 467
        WAN, 467
    client-server model and socket programming, 476–479
    communication services
        broadcasting, 466
        point-to-point and multicasting, 466
        types, 466
    data transmission, 465
    defined, 465
    IP, 476
    LAN
        architecture, 467–472
        standardization, 467
    MAN, 472–473
    packet-switched
        routing information, 466
        switching system, 465–466
    PAN, 476
    WAN, 473–476
    wireless networks and security issues
        components, 478–479
        modems, 478
        technology types, 481
        WLAN, 481–482
Computer numerical controlled (CNC) machining, 397
Computer systems for subsea controls system (SCA), 870
Condition-based maintenance
    automated performance assessment and manual audit agreement, 214, 215
    control performance monitoring software approaches, 215
    production-maintenance coordinator role, 217
    roles and responsibilities, 216–217
Condition Based Monitoring (CBM), 746
Confidentiality, 571, 572
Conformance
    class 1
        benefits, 637
        Ethernet equipment and TCP/IP protocol, 636
    class 2, 637
    class 3
        approaches, 637–638
        network topology, 638
        TDMA principle, 638
Constant failure rate
    exponential function, 737
    probability density function, 737
    stress-strength simulations, 737
Construction
    specification packages, 102
    specifications, 102
Content filtering, 501
Contention resolution
    OBS network core, 556
    OPS, 559
    photonic slot routing, 551–552
    unified, 561
Contextualisation
    alarms, 220
    enterprise-wide performance monitoring requirements, 221
    events, 220
    historian, 220
    laboratory, 220
    maintenance, 220
Continuous process
    control loop, continuous and fed-batch control, 14
    definition, 5
    flow and liquid pressure, 14
    level, 14–15
    manufacturing mode, 11
    mode, chilli, 18
    recycle streams, 14
Continuous time signal, 314–315, 325
Control
    alarm, 872, 873, 875, 878
    algorithm, 415, 416, 418–420
    architecture, 870–872
    block diagrams, 102
    design, 823
    electromechanical relay, 90–91
    error, 417–418
    event, 873, 874
    hardwire, 91
    integrated, 823–824
    methods, 415–417, 424, 428, 431, 432, 435, 436
    motor, 823–824
    network, 872, 875
    network diagrams, 102
    objective, 417, 418, 420, 432
    panel layout, 102
    panel vendor, 102
    panels controllers, 106, 107
    programmable logic controller, 91
    specifications, 824–825
    system, 872–876, 878–879
Control condition
    and diagnosis, 206–210
    oscillation monitoring, 204–205
Controllable, 419, 430
Controller algorithms
    characterizers, 237
    filters, 237
    non linear, 237–240
Controllers
    distributed, 868–869
    IT, 869
    networks, 869
    PLCs, 868
    protocol bridges, 869
Control loop execution
    period, 28
    process response, 28
Control loop objectives, 234

ControlNet™, 349
  application
    discrete output point and position sensor object, 660
    stations, 660
  architecture, 64
  communication profile, 658
  data link
    MAC cycle time and PDU, 658, 659
    NUT, 658
  description, 63–64
  network, 659–660
  physical, 658
  presentation, 660
  transport, 659–660
Control paradigm, 90
Control performance, 27–28
  audits, 203
  condition and diagnostic metric, 203
  control execution area, 28
  definition, 203
  execution rates, 28
  IO processing delays, 28
  metrics, 203–206
  monitoring, 203
Control performance metrics
  controller oscillation
    description, 204–205
    Fourier analysis, 205
    identification, 205
    time series and power-spectrum plots, 205
  variance, disturbance response
    calculation, impulse, 204
    CV, 204
    “variance ratio”, 204
Control performance monitoring software
  economic metric, 214
  requirements, 219–220
Control room, 704–705
  definition, 5
  design, 871–872
  location, 7
  new, 409–411
  operator console, 21, 22
  operator control station, 410, 411
  operators, 7–8
  refurbishment, 411
  screen display, 411
  working, 8
Control room design
  early fault detection and recovery, 409
  human centre process, 408–409
  instrumentation and control (I&C), 409
  manual and automatic, 409
  task analysis, 409
  user centered strategy, 409
  visualization tool, 409
Control room layout, 409, 412
Control service factor, 203, 206
Control software
  grid connected PV systems
    battery storage, 926, 927
    storage capacity, 929
  user’s simplicity, 925
  without grid connection
    control and optimization strategy, 927
    electric generator, 927
    self-supporting solar packages, 927
Control system configuration
  control languages, 23
  control strategies, 23, 24
  programming, 22–23
Control system requirements, 419
Control systems, 308
  continuous, 5, 14–15
  design
    hazard, 872
    integrity, 872–874
    operability, 872
    risk assessment, 874
    safety, 872–874
    SIL, 872–874
  discrete, 10–11
  hardware, 934
  implementation, 878–879, 934–936
  plant bus (PB), 933, 934
  selection, 874–876
  software, 930, 931, 934–937
Control variable (CV)
  limit
    activation, 211
    violation, 212
  prediction quality
    autocorrelation, error, 212
    model error diagnosis, 212–213
    MPC, 212
    spectral analysis, 212, 213
  steady-state, 211, 212
Conventional firewalls, 573
Conversion, 342–343
Convolution
  Fourier transform, 321
  integral, 315
  time domain, 316
Core-Based Tree (CBT), 492
Core exit thermocouples (CETs)
  fluid flow monitoring, 912–913
  PWR plants, 912
Cost of calibration, 145–146
Cost optimal
  accurate sensor network, 74–75
  automation-based sensor networks, 85, 86
  fault observation, networks, 83
Cost-optima sensor network
  actuators, 85
  dynamic operation region, 85
Costs
  batteries, 925
  craft labor, parts, and vendor support, 752
  deferred maintenance identification, 752
  hybrid cars, 925
  improvements, 752
  life-cycle, 752
  operating departments, 752
Counters
  down counter, 97, 98
  up counters, 97, 98
Counters/timers, 337
Couplers, 541
CPF, *see* Common packet format
CPFs, *see* Communication profile families
CPLD, *see* Complex programmable logic device
CPU, *see* Central processing unit
CPU and I/O, 101
CPU specifications, 94
CRC, *see* Cyclic redundancy check
Creating 3D objects
  control room design process, 408–409
  digitization techniques, 408
  laser scanners, 408
Creation, reports, 104, 106
Critical condition management (CCM), 716, 729–732
Cryptography, 502, 506
CSMA, *see* Carrier sense multiple access
Current optical networks
  SDH, 532
  SONET, 532
Current to voltage converter, 320
Cyber security
  attacks, 889–890
    application backdoors, 496
    buffer overflow and cyberbullying, 497
    described, 495
    DoS and DDoS, 496–497
    e-mail and network, 496
    instant messenger, 496
    investigation and analysis, 503
    malicious code insertion, 497
    OS bugs, macros and spam, 496
    redirect bombs and source routing, 496
    remote login, 496
    SMTP session hijacking, 496
    targeted, 498
    tool types, 495–496
  automation, 571–574
  categories, 889–890
  criminals, 498
  cyberethics, 503
  cyberspace regulation
    social problems and conflicts, 504
    WIPO Copyright Treaty, 504
  derivatives, 893
  hidden threats, 497–498
  industrial control systems (ICS), 571–574
  information technology (IT), 571–574
  ISA S99, 573
  management
    measures against attacks, 498–499
    properties, 498
  measures, 893–894
  mechanisms, 890–891, 895–896
  network framework
    information exchange, 499
    ISAC, 500
  network infrastructure
    attack detection, 502
    containment, 503
    content filtering, 501
    cryptography, 502
    digital signature, 502
    firewall, 500
    functions, 499
    intrusion prevention systems, 501–502
    IRT, 502
    penetration testing, 502
    security auditing, 502
    surface area reduction, 500

  - opportunistic attacks, 498
  - phishing and pharming, 498
  - profiles, 891–894
  - requirements, 889–890
  - solutions, 890–894
  - standards organizations, 494–495, 504
- Cyber Security Operations Center, 684
- Cyber security, power industry
  - assets, 887–888
  - deliberate threats
    - disgruntled employee, 888
    - hackers, 888–889
    - industrial espionage, 888
    - terrorism, 889
    - theft, 889
    - vandalism, 888
    - viruses and worms, 889
  - inadvertent threats
    - carelessness, 888
    - equipment failures, 888
    - safety failures, 888
  - requirements, 889–890
  - solutions
    - EC 62351-5, IEC 60870-5 and derivatives, 893
    - IEC 62351-4, MMS, 892
    - IEC 61850 profiles, IEC 62351-6, 893
    - IEC 62351 series, mechanisms, 890–891
    - TCP/IP, IEC 62351-3 series, 891–892
- Cyber standards organisations, 504
- Cyber vulnerable PLCs, 572
- CyboCon MFA control software
  - nonlinear
    - configuration, 423–424
    - controller, 423
  - pH controller, 424
  - SISO configuration, 422–423
  - time-varying and anti-delay controller, 424, 425
- Cycle times
  - definition, 5
  - network data, 631
  - reduction, 11
- Cyclic data exchange
  - definition
    - cycle time, 579
    - jitter, 579
  - message-based implementation, 579, 580
  - scheduler, 580
- Cyclic redundancy check (CRC), 286–287, 585

D

- DAC, *see* Digital-to-analog converters
- Dairy
  - automation
    - butter-making section, 800
    - cream pasteurization system, 800
    - hot water generation section, 801
    - milk collection center and quality check, 798
    - milk reception section, 798
    - pasteurization section, 799
    - pouch filling, 799–800
  - HMI, 801
  - process, 798
- Dairy industry
  - automation, 798–801
  - evolution and progress, 797
  - future trends, 802
  - HMI, 801
  - nature, 797
  - processing, 798
  - production, 797, 801
  - products, 797
- Dairy process
  - automation, 798–801
  - requirement, 801
- DAQ, *see* Data acquisition
- DAQ systems
  - multifunction I/O
    - analog output, 336
    - counter/timers, 337
    - digital I/O, 336–337
    - voltage levels, digital TTL signal, 337
  - multiplexers and multichannel systems, 335–336
  - timing controller, 336
- Data, 342–347, 350
  - acquisition, 200–202
  - analysis, 200–203, 362
  - autonomous collection, 201–203
  - equipment, 200
  - handling, 303
  - latency, 351–352
  - synchronization, 352
  - throughput, 351
  - visualisation, 362
- Data acquisition (DAQ), 344
  - A/D and D/A signal converters, 330–335
  - buses, 351–355
  - data handling, 351–363
  - defined, 330
  - elements, 330, 331
  - fundamentals, 330–341
  - hardware, 355–356
  - methods, 334
  - multifunction device, 330, 331
  - networks, 351–363
  - signal conditioning
    - amplification, 338
    - circuitry, 337, 338
    - filtering, 338
    - isolation, 338–339
    - sensor and transducer interfacing, 339–341
  - software, 356–363
  - systems
    - multifunction I/O, 336–337
    - multiplexers and multichannel, 335–336
    - timing controller, 336
- Data acquisition hardware, 328, 344
  - classified, 355–356
  - I/O boards, 355–356
- Data acquisition software, 356–358
- Data acquisition software device driver, 358
- Data acquisition systems, 344
- Data analysis
  - dynamic, 906, 907, 917
  - static, 906, 907, 917
- Data analysis and visualization, 362–363
- Data buffering, 359–360
- Data coding efficiency (η_{DC}), 583, 584
- Data destination, 861
- Data encryption standard (DES), 507
- Data handling, 351–363
- Data historian
  - activities integeration
    - Citecthistorian, 455–457
    - organization, 454, 455
    - Siemens SIMATIC IT, 455–456, 458
  - description, 454
  - functions, 454
  - perspective view, 454
  - product reengineering, 456, 459
  - SCADA, 454
- Data link layer (DLL), 468–469, 649–650
  - communication, scheduled and unscheduled, 601
  - device types, 601
  - LAS arbitrator, 600–601
  - link active scheduler operation, 602
  - list maintenance, 601–602
  - mechanism, 601
  - redundancy, 602
  - statement, 600
  - synchronisation, 602
- Data reconciliation
  - accuracy, 376
  - dynamic, 377–379
  - and gross error detection, 72–73, 75
  - steady-state linear, 367–370
  - systematic errors, 80
- Data reconciliation and methods, gross error detection
  - bias and leak, 370–373
  - canonical representation, 365–367
  - dynamic, 377–379
  - linear and steady-state problem, 364
  - multiple gross error, 373–377
  - software packages, 379
  - steady state linear, 367–370
  - variable classification, 364–365
- Data throughput, 351
- $d50_c$
  - classification efficiency, 840
  - determination, spigot opening, 840–841
  - graphical plots, 845
  - output signal, 840
  - percentage similarity coefficient (PSC), 844–845
- DCS, *see* Distributed control systems
- DCSs, *see* Distributed control systems
- DDNS, *see* Dynamic Domain Name System
- DDS, *see* Digital data services
- Delay time, 415–417, 424, 425, 428, 430, 432, 434, 436
- Deliberate threats
  - employee, 888
  - espionage, 888
  - hackers, 888–889
  - terrorism, 889
  - theft, 889
  - vandalism, 888
  - viruses, 889
  - worms, 889

Delta-sigma A/D converter, 334–335
Demodulator, 320–321
DES, *see* Data encryption standard
Design of experiments (DOE)
    experimental data collection, 443
    quantitative technology, 438
    sequential analysis, 442
    sequential empirical optimization, 439
Design tools, 194, 436
Development of standards
    consensus, 153
    industry-wide, 153
    ISO, 152–154
    national and international, 152
    voluntary, 153
Device
    description (DD), 66–67
    device type management, 68–69
    engineering, 67
    interchangeability, 67
Device description language (DDL), 593
Device driver, 358–363
Device driver software
    buffering, 359–360
    calibration, 358–359
    configuration, 358
    data link library, 358
    management, 359–360
    multithreading, 359
    synchronization, 359–360
    timing, 359–360
    triggering, 359–360
Device management, 630
DeviceNet layers
    application
        CIP protocol, 657
        connections types, 657
        Predefined Master–Slave Connection Set, 657
    communication profile, 654, 656
    data link
        CAN data frame and arbitration phase, 656, 657
        dominant and recessive, 656
        MAC and LLC, 655
    physical, 654–655
DeviceNet^{TM}, 349, 858
Devices
    control, 132, 138
    monitoring, 138
Device type manager
    DDL technology, 611
    FDT 2.0, 612
    IEC 62453 status, 612
    "nested communications", 613
    types, DTMs, 612
DHCP, *see* Dynamic Host Configuration Protocol; Dynamic host configuration protocol
Diagnostics, 861, 875, 878
    DCS, 25
    electrode impedance, 33
    PCN, 32
Dial up topologies, 288
Differential equation representation, 316
Differentiator, 319–320
Digital
    filters, 326–327
    FIR, 327
    IIR, 327
    signal processing (DSP), 323–325
Digital computer
    application-specific computer-embedded systems, 303
    architecture, 306
    reliability, control systems, 307
    smaller, faster and cheaper, 308
Digital control, 10
Digital data services (DDS), 288
Digital I/O, 336–337
Digital manufacturing
    DELMIA, 814–815
    description, 814
    PAC and design software integration, 814, 815
Digital signal processing (DSP) software
    A/D and D/A converter, 325
    algorithms, 323
    conditioning, 327–328
    conversion steps, 328
    development, 328–329
    digital inputs and outputs, 328
    discrete-time signal, 328
    mathematical approach, 325–326
    MATLAB functions, 328
    microinstruments, 324
    microprocessor-based instrument, 324
    packages, 329
    software support, 327–329
    tunable FIR filter design, 328
Digital signal processors (DSPs)
    definition, 303
    microprocessors, 305
    storage capability and flexibility, 306
    wireless chips, 305
Digital signal transmission
    IEC 61158 standard, 347–348
    Modbus, 344–347
    protocols, 348–350
    wireless transmission, 350
Digital technology
    computer architecture, 306–308
    data acquisitions, data processing and control, 303
    DSPs, 304–306
    FPLDs, *see* Field programmable logic devices
    microcontrollers, 304
    microprocessors, 304
    reconfigurable systems, 308–309
Digital-to-analog conversion, 342
Digital-to-analog (D/A) converters
    capacitive, 331
    characteristics, 332
    design, 332
    IC, 331
    linearity, 332
    monotonicity, 332
    operation, 332
    resistive, 331
    resolution, 332
Direct acting, 422, 430
Direct digital control (DDC), 8
Directed graphs (DG), 83
Direct sequence spread spectrum (DSSS), 47, 291, 292
Disconnect, grid, 922
Discrete manufacturing, 10–11
Discrete time signal, 314–315
Discrete time sinusoidal signal, 325
Dispersion, 534
Display panel operations
    action buttons, 108–109
    EFSO screen conventions, 107–108
Distributed
    energy, 887
    resources, 887
Distributed control, 861, 862, 867–868
    DCS, *see* Distributed control systems
    networks, *see* Distributed control networks
Distributed control networks
    corporate networks, 31
    plant networks, 31–32
    topologies, 29–31
    virtual private networks (VPN), 29–30
    wireless HART, 31, 33, 37
Distributed control systems (DCSs), 415, 416, 421, 437, 698, 850
    architecture, 57
        alarms, 26, 27
        alert processing, 26–27
        conventional IO, 25
        diagnostics, 25
        functional components, 20–21
        historical data, 25
        input/output cards, 24–25
        integration, 26
        operator console, 22
        process control networks, 21–22
        redundancy, 25
        security, 25–26
        system configuration, 23–25
    automation
        ISA, 12, 26, 34, 37
        process, 31
        types, 10, 11
    business drivers, 37
    classification
        batch processes, 11, 17
        continuous processes, 10, 14–15
        discrete and process manufacturing systems, 10
        fed-batch systems, 11
        integrating response, 16–17
        modes, systems and controls, 11
        process manufacturing systems, 10
        profile control, 19–20
        safety systems, 12–14
        self-regulating processes, 15
    development, 56
    "easy to configure", 56, 57
    ESD system, 873, 875, 877
    evolution
        advantages, predecessors, 8–9
        architecture, 9
        controllers, linking devices, 9
        data capture and analysis, 8
        Ethernet technology, 9
        Foundation Fieldbus, 9

    - low cost microprocessors, 8
    - multi-loop and pneumatic controller, 8
    - panel-based system, 10
  - fieldbus standardization, 56
  - field devices, 31, 33
  - IOs, 24–25, 28, 36
  - laboratories, 8
  - LAN system architecture, 277
  - microprocessor, 276
  - modern automation, 803
  - monitoring and status signals, 876
  - network integration
    - design principles, 34
    - equipment packages, 36
    - field instruments, 36
    - IT security, 34
    - office environment, 34
    - plant environment, 34–36
    - process and office network, 34
    - process control device connectivity, 36
    - wireless networks and devices, 36
  - networks, digital
    - ACN, 33
    - corporate, 31
    - field, 33
    - PCN, 32–33
    - plant, 31–32
    - topologies, 29–31
    - wireless, 33–34
  - OT, 870
  - performance requirements, 27–29
  - plants and
    - maintenance, 8
    - operators, 7–8
    - organization, 6–7
    - structure, 6
  - and PLCs, 806
  - subsea wells and ancillaries, 870
- Distributed energy resources (DER)
  - communications, 887
  - devices manufacturers, issues, 887
- Disturbance, 415–418, 420, 424, 426–427, 429, 434–436
- Disturbance in production
  - capacity, 774
  - energy, 774
  - information, 774
  - input, 774
  - material, 774
  - source, 774
- Disturbances
  - in automobile plant, 775
  - definition, production control, 774
  - FAS execution, 767
  - fluctuation, production flow, 773
  - OPQS indicator value, 776
  - production control and management, 765
  - source, 774
  - synchronization, assembler and supplier, 772
  - types identification, 776
- DLL, *see* Data link layer
- DNP protocol, 285, 286, 289
- DNS, *see* Domain Name System
- 3D objects
  - CAD package, 408
  - design software, 408
  - photogrammetry techniques, 408
  - texture production, 408
- Documents
  - NEC articles, hazardous areas, 713, 715
  - NFPA, 713, 714
- DOE, *see* Design of experiments
- Domain Name System (DNS)
  - distribution, domain name, 491
  - ICANN, 491–492
  - server, 481
- DPM1, *see* DP Master class 1
- DPM2, *see* DP Master class 2
- DP Master class 1 (DPM1), 616
- DP Master class 2 (DPM2), 617
- Driver software, 358–363
- DSPs, *see* Digital signal processors
- DSP software development, 328–329
- DSSS, *see* Direct sequence spread spectrum
- Dynamic data reconciliation
  - discrete estimator, 377–378
  - filtering and smoothing, 377
  - integral, 378
  - linear estimator construction, 377
  - nonsmooth signals, 369
  - smoothing approach, 378
  - software vendors, 379
  - state estimation problem types, 377
- Dynamic Domain Name System (DDNS), 492
- Dynamic Host Configuration Protocol (DHCP), 54, 488, 631–632
- Dynamic link library, 358

E

- e-Calibration, 146–147
- ECC, *see* Elliptic-curve-cryptography
- Economic value of data, 74
- EDD, *see* Extended device description
- EDDL, *see* Electronic device description language
- EDDL products
  - device description (DD), 611–612
  - hierarchy, 612
  - interoperability, 612
  - services, 612
- EDDL *vs.* FDT, 613
- Effective isotropic radiated power (EIRP), 291
- Effective radiated power, 296
- Effective service factor (SF_E)
  - and SF, 206–207
- EIA, *see* Electronic Industries Association
- EIRP, *see* Effective isotropic radiated power
- Electric cars, 921, 924–927, 929
- Electric meters, bidirectional, 921
- Electrolyzer, 921–922, 928, 929
- Electronic
  - records, 807–808
  - signature, 807–808
- Electronic batch records (EBR) system, 189–190
- Electronic calibration, 146–147
- Electronic device description language (EDDL)
  - definition, 611
  - electronic data description (EDD), 611
  - *vs.* FDT: FDI, 613
  - fieldbus foundation products, 611–612
- Electronic Industries Association (EIA), 494
- Electronic mail (E-mail)
  - attack, 496
  - described, 490
- Electronic recording, 807–808
- Electronic signatures, 189–190
  - automation system, 807
  - HMIs, 806
  - primary regulation, 803
  - and records, 806
- Electro-optic (EO), 537
- Elliptic-curve-cryptography (ECC)
  - *vs.* RSA, 508
- E-mail, *see* Electronic mail
- Embedded system
  - application-specific computer, 307
  - architecture, microcomputer, 306
  - CPUs and memory, 306
  - custom IP, 311
  - FPLDs, 309
  - microprocessors, 304
  - types, 309
- Empirical modeling, 255
- Emulation emulator, 401–402, 404
- Encapsulating security payload (ESP), 521
- Encapsulation, 562, 563, 707
- Encoding rules
  - data, 138
  - length, 138, 139
  - type, 138, 139
- Encryption
  - algorithms, 521–523
  - asymmetric
    - algorithms, 522–523
    - digital signatures, 522
    - process, 522
    - public and private key, 522
  - factors, 522
  - private key, 506–508
  - public key, 508–509
  - RSA, 522
  - symmetric, 522
- Energy
  - alternative, 919–938
  - renewable, 919–929
  - thermal, 928, 930–938
  - wind, 931
- Energy consumption, global, 919, 920
- Energy free homes
  - PV collectors and control, 922–924
  - PV systems, 921–922
  - solar hot water systems, 921
  - solar shingles, 920–921
- Engineering changes, 755
- Enhancing safety culture
  - commitment, 733–734
  - equipment, 734
  - procedures, 734
  - reporting, 734
  - responsibilities, 733–734

  training, 734
Enterprise asset management (EAM)
  commercial and technical management, 40
  definition, 41
  physical model, 41
Enterprise control function model, 179
Enterprise management, 43
Enterprise resource planning (ERP), 415, 578, 702, 703
  client-server architecture, 278
  plant control networks, 280
  systems, 280
Enterprise-wide
  control performance, 217–227
  data preprocessing, 219
  measure, 218–220
  orchestration, 222, 224–227
  software requirements, 217–227
  universal connectivity, 219
EO, *see* Electro-optic
EPL, *see* Ethernet powerlink
EPL data link layer protocol
  Ethernet mode, 645
  power mode, 645
EPL frame structure, 647
Equipment database structure, 755
Equipment packages, 36
ERP, *see* Enterprise resource planning
Error deadband, 423
Errors
  gains and offsets, instrument, 146–147
  random, 143, 145
  randomness, 142
  and uncertainties
    type A, 142
    type B, 142
    "user calibration", 141
ESP, *see* Encapsulating security payload; Ethernet switched path
EtherCAT, 349
  addressing, 650–651
  architecture
    addressable devices, 649
    Manchester violation, 648–649
    master process, 648
    physical layer, types, 648
  commands, 651–652
  distributed clock, 652
  frame structure and DLL, 649–650
  network architecture, 648–649
  ring topology, 648
  state machine, 652
EtherCAT state machine, 652
Ethernet, 354–355
  equipment, 64, 65
  fieldbus, 64–65
  PROFINET, 64
Ethernet frame
  encapsulation, 563
  stacking, 563
  tagging, 562
EtherNet/IP™, 349
  CIP model
    attributes, 640
    device, 640–641
    stack, physical and data link layers, 641
  connection types
    behavior, 642, 643
    transport classes, 642
    UCMM, 641–642
  explicit message
    encapsulation protocol, 642, 644
    point-to-point, 642
  I/O message
    CPF, 643–644
    data transmission, 643
    uses, 642
Ethernet LAN, 470–471
Ethernet POWERLINK, 349
Ethernet power link (EPL)
  application layer protocol, 647–648
  architecture, 644–645
  CN communication classes, 646
  DLL protocol, 645
  features, 644
  frame structure, 647
  MAC layer, 645
  network topology, 647, 648
  physical layer, 645
  powerlink cycle, 645–646
Ethernet switched path (ESP)
  PBB-TE, 563
  P-OTNs, 561
ETS, 349
European Committee for Electrotechnical Standardization (CENELEC), 581
European standards, 581–582
EVDO, *see* Evolution data optimized technology
Evolution data optimized (EVDO) technology, 297
Examples
  heat exchange, 272
  model parameter adjustment, 273
  pH neutralization, 273
Examples of calibration
  chemical, 148
  dynamic pressure, 149
  sensors, 148
  static pressure, 148–149
Existing plants, 701
Expansion buses, 352–353
Exploration and production company in India, 870
Explosion proof, 59, 707, 711
Explosion proof housings
  description, 706
  flamepath, threaded joint, 711
  sealing devices, addition, 711
Extended device description (EDD), 622, 623, 628
Extended Mark-Up Language (XML), 632, 634
External buses
  Ethernet, 354–355
  GPIB, 353
  networks, 353–355
  universal serial bus, 354
External expansion buses
  backplane, 352
  IC, 352
  mezzanine, 352
  PCI, 353
  PCI Express, 353
  PXI, 353
  SoC, 352

F

Facility standards, 699–700
Factory instrumentation protocol (FIP), 347, 348
Factory Mutual (FM), 707, 713, 727
Fade
  margin, 294
Failure modes
  annunciation, 739
  fail-danger, 738–739
  fail-safe, 738
  microcomputer-based system, 738
  PLC, 738
Failures
  bathtub curve, 736, 737
  device designer, 736
  exceeding stress, 736
  infant mortality, 736
  rates, 736, 737
  and redundancy considerations
    physical medium, 584
    station, 584–585
    transmission errors, 585
  and repair codes, 755
  useful life, 736, 737
  wearout, 736
FAS, *see* Final assembly schedule
Fault detection, 74, 83, 607
Fault diagnosis, 203
  degradation, 82
  direct graph (DG), 83
  gross error detection, 82
  malfunction, 82, 84
Fault resolution
  maximum fault resolution, 83
Faults
  observability, 73, 83
  resolution, 73, 83
Fault tolerance, 197–198
Fault tolerant control (FTC), 856
FC, *see* Fuel cells
FCC, *see* Federal communications commission
FCS, *see* Frame check sequence
FCs types, *see* Function codes types
FDLs, *see* Fiber delay lines
FDMA, *see* Frequency division multiple access
Fed-batch process
  batch variables, 19
  cell culture bioreactors, 18–19
  control systems, pure-batch, 17–18
  mode, chilli, 18
  pressure and temperature loops, 18
Federal communications commission (FCC)
  licensed bands, 290
  radio spectrum allocation, 289
  unlicensed bands, 291
Feedforward
  gain, 427, 428

  MFA controller, 421, 426–429
  time constant, 427
FHSS, *see* Frequency-hopped spread spectrum
Fiber cross-connect (FXC), 548, 549
Fiber delay lines (FDLs), 560, 561
Fiber-optic, 869
  communication, 869
  components, 541–542
  networks, 525–532, 869
Fiber-optic communications
  lightpaths, 546
  network, 546–564
  OBS network core, 555–556
  optical add-drop multiplexer, 547
  optical burst switching, 553–555
  optical cross-connect, 547–548
  optical flow switching, 552–553
  optical packet switching, 556–561
  packet optical transport network, 561–563
  photonic slot routing, 550–552
  reconfigurable optical add-drop multiplexer, 547
  transmission medium, 546
  waveband switching, 548–550
  WDM, 546
Fiber-optic networks
  access schemes, 529–530
  amplifiers, 539–541
  attenuation and loss, 533–534
  communication, 525–526
  current and next-generation, 532
  description, 532–533
  dispersion, 534
  first-generation, 528–529
  information channels and transport, 528
  light sources, 535–536
  multiplexers/demultiplexers, 538–539
  nonlinearities, 534–535
  passive components, 541–542
  protocols and services, 527–528
  receivers, 536
  regeneration, 542
  switches, 536–538
  topologies, 530–532
  types, 527
  wavelength conversion, 543
Fieldbuses, 347–349, 858
  definition, 578
  functions
    asynchronous traffic, 581
    cyclic data exchange, *see* Cyclic data exchange
    field and cell levels, 578–579
    messaging, 581
  industrial communication systems, *see* Industrial communication systems
  performance, 582–584
  redundancy and failure considerations
    physical medium, 584
    station, 584–585
    transmission errors, 585
  standardization, 581–582
Fieldbus intrinsically safe concept (FISCO) model
  approval, 627
  category, 627
  explosion group, 627
  grounding, 627
  intrinsic safety, 626
Fieldbus message specification (FMS), 602–604
Fieldbus protocols
  Foundation Filedbus, 46–47
  HART, 47
  PROFIBUS, 46, 47
Field device tool (FDT), 612–613
Field instrumentation
  hazardous areas, 66
  P&ID, 878
  safety integrity level, 65–66
Field instruments
  conventional IO, 36
  fieldbuses, 36
  local control bus, 36
Field I/O, 101–103
Field networks, 33
Field programmable gate arrays (FPGAs), *see* Digital technology
Field programmable logic devices (FPLDs)
  four SoC, 311
  FPGAs and CPLDs, 309
  PALs and PLAs, 309
  read-only memory (ROM), 309
  system chip, 311
Field sites
  data destination, 862
  protocols, 862
File Transfer Protocol (FTP), 489
Filter, 423
  analogue, 321–323
Filtering
  aliasing, 338
  low-pass filter, noisy signal, 338, 339
Filtering isolation, 338
Final assembly schedule (FAS)
  constraints and availability, material, 767
  elaboration process source, 767, 768
Finite element (FE) simulations, 781
Finite impulse response (FIR), 327, 328
FIP, *see* Factory instrumentation protocol
FIR, *see* Finite impulse response
Fire
  detection, 877
Fire and gas detection system, 877
Firewalls
  application level gateways, 500
  packet filters, 500
  principles, 500
  use, 500
Firmware, 387
First generation optical networks, 528–529
FISCO model, *see* Fieldbus intrinsically safe concept model
Five-unit three-node system
  canonical representation
    Gauss–Jordan factorization, 366
    matrix manipulation, 365–366
    measurement, variables, 366–367
  material balances, 364
  redundant and non-redundant variable, 365
  variables
    measured and unmeasured, 365
    observable and unobservable, 365
FL, *see* Fuzzy logic
Flamepath
  explosion proof housing
    flat ground joint, 711
    threaded joint, 711
Flameproof, 706, 707
Flammable
  gas and vapor/liquid, 708, 709
  materials, 707
Flash A/D converter, 333–334
Flash point, 708
FLC, *see* Fuzzy logic control
Flexibility and scalability, 728–729
Flexible manufacturing systems (FMS), 160
  simulation, 397
  and transfer-type line, 396–397
Flex-phase MFA controller, 416
Flotation
  control
    FrothMaster and JKFrothCam systems, 853
    operator support systems, 853–854
    PI controllers and airflow rates, 852–853
  described, 851
  instrumentation
    electrochemical measurements, 852
    process flowsheet, 852, 853
    slurry flow measurement, 851–852
    X-ray fluorescence method, 852
Fluid flow monitoring
  cross-correlation principle, 913
  detector placement and noise data record, 913, 914
  frequency domain phase analysis, 913, 914
  thermocouples, 912–913
  transit time, 913
FMS, *see* Fieldbus message specification
Follow up activity
  event trigger, 224
  responsibility, 224–226
  results tracking, 226
Forecasting, 940, 943, 947
Fostering safety culture, 733, 734
FOUNDATION™ Fieldbus, 348, 349
Foundation Fieldbus (FF) software, 875, 877–878
  configuration, 614
  conformance test, 614
  engineering tool, 613–614
  features, 598
  H1, 599–604
  H1 and HSE, 607–608
  HSE, 44, 50, 53, 62, 604–607
  interoperability, 614
  open systems implementation, 611–613
  principles, 598
  technical description, 598–599
  tokenizer, 614
  wireless solutions, 608–611
Fourier transform

  defined, 316
  digital (DFT) and fast (FFT), 314
  inverse, 316
  and Laplace transform, 317
  signal analysis, 325
FPLD, *see* Field programmable logic devices
Frame
  relay, 288
  routers, 288
Frame check sequence (FCS), 585
Frame Relay Forum, 494
Frequency division multiple access (FDMA), 296
Frequency-hopped spread spectrum (FHSS)
  dwell time, 292
  2.4–2.4835 GHz, 292
  5.725–5.85 GHz, 293
  high bit rate, 292
  902–928 MHz, 292
  same band, minimal interference, 292
Frequency modulation (FM), 320, 321
Frequency response, 234
  magnitude representation, 317
  phase representation, 317
Frequency-selective filters, 322
FTC, *see* Fault tolerant control
FTP, *see* File Transfer Protocol
Fuel cells (FC)
  controlling, 929
  hydrogen, 928, 929
  reversible, 920, 928–929
Full duplex, 284, 285
Function blocks, 729
Function block scheduling, 603, 608, 609, 614
Function codes (FCs) types, 639, 640
Functions
  access portal, 454
  analysis, 454
  data collector, 454
  historize, 454
  notify, 454
  organize, 454
  store, 454
  visualize, 454
Fuzzy
  defuzzification, 844
  fuzzification, 243, 268
  implementation, 844–845
  inference, 843–845
  rules, 843–846
  system, 843–846
  values, 843
Fuzzy controller
  billets, 792–793
  heating, 792–793
  inductive, 792–793
Fuzzy logic (FL), 243
  automation examples, 271–273
  concepts, 266–269
  control, 269–271, 789–794
  defuzzification, 791, 792
  fuzzification, 792
  sets, 791–793
Fuzzy logic concept
  linguistic categories, 266–269
  membership, 266–269
Fuzzy logic control (FLC)
  automation, 271–273
  concepts, 266–269
  process control, 269–271
  processes, 265–274
  reasoning, 265, 266
FXC, *see* Fiber cross-connect

G

Gain and loss functions, 322
Gain ratio, 429
GAMP-V model, 804, 805
Gas
  detection, 877
Gas mixing
  process, 434
  system, 434, 435
Gas producing and processing plant, 870
General features
  H1 segment, 605–606
  HSE segment, 605, 606
  protocol, 605, 606
Generalized binary noise (GBN) approach
  closed-loop, 245, 246, 248
General packet radio service (GPRS), 297
General purpose computer
  information system, 308
  memory size and peripheral set, 306
General purpose interface bus (GPIB), 353
General Station Data Mark-Up Language (GSDML), 634
Generic access protection architecture
  access controller, 568, 569
  firewall, 568
  proxies, 568
  security gateways, 568
  user
    ACS, 569
    agent, 568, 569
    network access controller, 568, 569
GEOS, *see* Geosynchronous earth orbit satellites
Geosynchronous earth orbit satellites (GEOS), 298
Global energy consumption, 919, 920
Global positioning system (GPS)
  mining
    open pit, 849
    underground, 850
  time synchronization, 875
Global system for mobile communications (GSM), 297, 481
Good engineering practice
  common engineering documents, process automation, 806
  GAMP V-Model, 805
GPIB, *see* General purpose interface bus
GPRS, *see* General packet radio service
GPS, *see* Global positioning system
Gray box, 417, 436
Grid
  batteries, 926–927
  connection, 926–927
  no connection, 927–929
Grid connected homes, 924–927
Grid connected inverters, 922, 923
Grid connected PV
  battery storage, 926–927
  no connection, 927–928
Grid disconnect, 922
Grid interface
  communication, 945
  control, 944, 945
  infrastructure, 945
Grinding
  control, 851
  instrumentation, 851, 852
Grooming, 549–550
Gross error
  equivalency
    limitation, 375
    multiple biases, 374
    sets, 374–375
  objective functions
    Fair function and Lorentzian distribution, 376
    mixture distribution, 375–376
  size estimation, 375
GSDML, *see* General Station Data Mark-Up Language
GSM, *see* Global system for mobile communications

H

Half duplex, 284, 285
Hamming distance, 585
Handling non linearity
  tools, 248–251
Hardkey, 427
Hardware
  actuator, 84
  architecture, microcontrollers, 307
  cost relation, 85
  definition, 303
  DSPs, 305
  redundancy, 72
  variable estimation, 73
Hardware redundancy, 72, 77
Hardware simulation, 360
Hardware structures, process automation networks
  application layer, 54
  communication models, 43–45
  communication relationships, 53
  EAM, *see* Enterprise asset management
  fieldbus
    AS-i, 60
    "Hunk 1" and "Hunk 2", 59
    IEC 61158, 48, 59–60
    4-20mA/HART, 60–61
  field instrumentation
    hazardous areas, 66
    safety integrity level, 65–66
  foundation fieldbus, 62–63
  industrial
    distributed control system, 56–57
    PLC, 55–56
    SCADA systems, 57–58
  information requirement and flow, 41–43

  - logical link and media access control, 51–52
  - media access methods, 52–53
  - modbus, 63–65
  - net-wide data exchange, 69–70
  - network layers, 53–54
  - OSI, 45–49
  - profibus dp/profibus pa, 61–62
  - security
    - components, 58–59
    - IT policy, 58
  - topologies, 50–51
  - transmission, 51
  - transmission medium, 49–50
  - transport layer, 54
  - variables, integration
    - device, 66–67
    - engineering, 67
    - interchangeability, devices, 67
    - OPC server, 67–68
    - plant asset management, 68–69
- HART, *see* Highway addressable remote transducer
- HART communication
  - current loop, 589–590
- HART devices
  - calibration, 595–596
  - installing, 595–596
  - intrinsic safety, 595
  - primary/secondary master, 595
  - troubleshooting, 596
  - wiring, 594–595
- HART protocol
  - revision, 596
- Hazard and operability study (HAZOP), 872
- Hazard and risk analysis, processes safety
  - ALARP, 724–725
  - certifications, 727
  - definition, 724
  - fire and gas monitoring, 726
  - graph, 725–726
  - IEC 61508 and 61511, 724
  - integrity level determination methods
    - factors, 725
    - qualitative method standards, 725
  - ISA technical report
    - fire and gas system, 726–727
    - ISA-84, 726
  - semi-quantitative analysis techniques, 725
- Hazardous area classification standards
  - North America, 708–710
- Hazardous area equipment
  - explosion proof, 711
  - intrinsically safe, 711–712
  - IS barriers, 711–712
  - sealing, 711
- Hazardous areas, 66
- Hazardous areas, North America
  - classification, 708–710
  - combustible materials, 706–707
  - combustion triangle, 713
  - definitions, 707–708
  - documents, 713–715
  - electrical equipment
    - explosion proof housings, 706
    - intrinsic safety (IS) barriers, 706
    - purging, 706
  - equipment, 710–712
  - flammable material, 707
  - installation, 707
  - management, 706–715
  - NEC, 706
  - purging, 712–713
  - safety systems, 707
- Head mounted display, 407
- Heartbeat, 421
- Heartbeat logic, 421
- Heating process
  - physical parameter, 785–786
  - simulation, 785–786
- Heating value, 434
  - soft-sensor, 434
- Heuristics, 273, 274
- H1 Foundation Fieldbus
  - data link layer (DLL), 599–602
  - physical layer (PhL), 600
- Hidden threats
  - bots, 497–498
  - malware, viruses and Trojans, 497
  - spyware, worms and rootkit, 497
- High-level diagnosis, 222
- High level languages
  - BASIC, 387, 389
  - C, 387, 389
  - C++, 387, 389
- High speed Ethernet (HSE)
  - foundation fieldbus
    - application layer, 606
    - features, 604–606
    - H1 and HSE interconnection, 605–606
    - physical, data link, network, and transport layers, 606
    - redundancy, 607
    - system and network management, 606–607
  - and H1, user application layer, 607–608
  - *vs.* ISO OSI architecture, 599
  - test tools
    - conformance, 614
    - interoperability, 614
- Highway addressable remote transducer (HART), 585, 875, 878
  - application layer, 593
  - benefits, 597
  - communication speed, 594
  - comparison to FF, 597
  - controllers and field devices, 595–596
  - DDL, 593–594
  - host conformance class, 596
  - long address *vs.* short address, 594
  - 4–20 mA current-loop transmitters, 589–590
  - network connections, 591
  - network layer, 593
  - OSI, 591–593
  - physical layer, 591–592
  - process variables, 590
  - protocol revisions, 596
  - transport layer, 593
  - wireless, 596
- Historical
  - data, DCS, 25
  - log, 111
  - trends, 104, 106, 111, 115
- HMI, *see* Human machine interface
- HMI development
  - alarm management, 106
  - basic navigation test, 106
  - building blocks creation, 105
  - color schemes, 105
  - connection, controllers, 106
  - control panels/pop-ups, 105–106
  - defined, 104
  - historical trends, 106
  - home screen and process screens, 105
  - middleware tag definitions and configurations, 105
  - navigation schemes, 105
  - pre-FAT tests, 106
  - preliminary configurations, 105
  - reports, 106
  - set-up screens, 106
  - tag database loading, 105
  - testing set, screens, 106
- HMI hardware, 101, 104, 105
- HMI software
  - concepts, 104
  - database loading, 104
  - screens, 104, 105
  - system configuration, 104
  - tags, 104
- Homes
  - energy-free, 920–924
  - grid connected, 924–927
- Host configuration
  - FTP, 488
  - MAC, 487–488
  - NIC, 488
  - TTL, 488
- Host conformance class, 596
- Hot water collector, 921
- Hot water generation, 801
- Hot water, solar, 921–923
- HSE, *see* High speed Ethernet
- HSE Foundation fieldbus
  - application layer, 606
  - features, 604–606
  - H1 and HSE interconnection, 605–606
  - physical, data link, network, and transport layers, 606
  - redundancy, 607
  - system and network management, 606–607
- HTML, *see* Hypertext Mark-Up Language
- HTTP, *see* Hypertext Transfer Protocol
- Human machine interface (HMI), 702, 703, 806
  - alarms
    - corrective operator response, 831
    - equipment status, 831
    - filterable, 831–832
    - priority definition, 831
  - display standards
    - alarms and status, color and shape, 830
    - colors, 829–830
    - elements, 830
    - gray scale, 830

        limited static/redundant information, 830–831
        status and animation, 830
    essentials, 101–102
    evolution, 828
    hardware, 101, 104–106
    high performance, 828–829
    software, 102, 104–105, 111
    workstations, 102, 105, 106
Human rules, 273
HVAC system, 434
HVAC system automation, 808
Hybrid signal systems, 343–344
Hydrocyclone
    centripedal force ratio, 840
    continuous flow systems, 840
    control, 840–841
    d50, 740
    $d50_c$, 740
    signal processing
        control parameters, 841
        hydrocyclone instrumentation, 841
Hydrogen system, 928
Hypertext Mark-Up Language (HTML), 487, 632
Hypertext Transfer Protocol (HTTP), 487, 632

I

I&C, *see* Instrumentation and control
ICMP, *see* Internet Control Message Protocol
Ideal solution
    central limit theorem, 441
    perfect knowledge, 441–442
IEC, *see* International Electrotechnical Commission
IEC 61131, 809, 814
IEC 61158, 348–350
IEC 61400-25, 947, 948
IEC 61784, 348
IEC 61158 fieldbus standard, 581, 582
IEC 61131-3 standard, 437
IEC 61158 Transmission standard
    layer 1, 347
    Layer 2, 347
    Layer 7, 347
IEEE, *see* Institute of Electrical and Electronics Engineers
IEEE 802, 344, 350
IEEE 802.11, 355
IEEE 802.15.4, 355
IEEE 1451, 343
IEEE Code of Ethics, 675
IEEE Risk Management model, 681
IEEE-1451 standard
    description, 132
    modular architecture, 132–133
    NCAP information model, 132
    sections, 132
    sensor node, 135
    TEDS structure, 133
If then, 269–273
IGMP, *see* Internet Group Management Protocol
IIR, *see* Infinite impulse response
IKE, *see* Internet key exchange
IMP, *see* Interface message processor
Implementations of robots
    automation, steps, 162–163
    development, 161
    industrial, 164
    installation and production, 162
    mock-up, 161–162
    planning, 161, 163–164
    vs. robot/human combination, 164
Impulse response
    convolution integral, 315
    FIR and IIR, 327
    Fourier transform, 317
    Laplace transform, 316
Incident response team (IRT)
    containment, 503
    mechanisms, 502–503
Inductive heating
    fuzzy controller design, 792
    notation, 782
    user interface, 791
Inductor, 318, 322
Industrial communication systems
    cell level, 578
    data exchange, 578
    device, 578
    plants automation, 578, 579
Industrial control systems (ICS)
    attack, 271–272
    security, 271–274
Industrial Ethernet
    EPL, 644–648
    EtherCAT, 648–652
    Ethernet/IP, 640–644
    Modbus TCP, 638–640
    taxonomy, 636–638
Industrial networks
    DCS, 56–57
    distributed I/O, 811, 812
    fiber-optic media, 818
    PLC, 55–56
    SCADA systems, 57–58
Industrial, scientific, and medical (ISM) bands, 291, 293
Infinite impulse response (IIR), 327
Information
    classification, 679
    control, 41
    flow, 41–43
    ownership, 679
Information systems, 308
Input/Output cards
    communication interface cards, 24
    conventional IO, 25
    multiple processors, 24
    sequence of events (SOE) input cards, 25
Inputs
    analogue, 103
    digital, 102
    4-20mA, 103
    module, 91–92
    scan, 94
    serial voltage, 103
    sinking type, 91, 92
    sourcing type, 91, 92
Institute of Electrical and Electronics Engineers (IEEE), 342, 494
Instrumentation and control (I&C)
    practices *vs*. OLM practices, 908, 909
    sensors, 907, 909
Instrumentation design goals
    accuracy, 73
    cost, 73
    estimablity, 73
    precision, 73
    reliability, 73
    robustness, 73
Instrumentation of hydrocyclones, 841
Instrumentation, processes and automation
    data reconciliation and gross error detection, 72
    design goals
        cost-based mathematical programming, 73
        designer, 73
        economic value, data, 74
        fault detection, 73–74
    malfunction, 72
    measured and key variables, 73
    parameter estimation, 75
    precision-constrained problem, 74–75
    precision upgrade
        constraints, 76
        industrial heat exchanger network, 76–77
        minimum cost problem, 76, 77
        on-line optimization, 76
        performance ways, 75
    redundancy classification, 72
    resource reallocation, 77–78
    sensor networks
        automation, 84–85
        automation-based cost-optimal, 85
        cost optimal accurate, 74
        design, process fault diagnosis, 82–84
        economic value-optimal, 81–82
        process fault resolution, 83
        reliable, 78–79
        repairable, 79–80
        robust, 80–81
    tree enumeration procedure, 75
Integrated Absolute Error (IAE), 15
Integrated sensors, 139
Integrated services digital network (ISDN), 475
Integrating calibration with CMM, 145
Integration
    device integration, 66–67
    engineering, 67
    interchangeability, devices, 67
    OPC server, 21, 26, 67–68
    plant asset management, 68–69
    process variables, 66–69
Integration of historian
    citect historian, 455–457
    data, organization, 454–456
    Siemens SIMATIC IT, 455–456, 458

- Integration response, 16–17
- Integrators
  - and differentiators, 319–320
  - op-amp circuit, 320
- Integrity, 272, 273
- Intelligent
  - instrument, 130–132
  - networks, 136–139
  - protocols, 136–138
  - sensors, 132–135
  - software, 132, 136, 138
  - standards, 132–133, 136, 139
- Intelligent electronic devices (IED)
  - IEC 61850-5, 897–898
  - privilege management infrastructure (PMI), 898
  - substation system, *see* Substation system
- Intelligent instruments
  - flowmeters, 130–131
  - functions, 130
  - pressure transmitters, 131–132
  - structure, 130, 131
  - temperature transducers, 131
- Intelligent modems, 289
- Intelligent sensor communication
  - capability, 135–136
  - multicast publish, 134
  - server model, 134
- Intelligent sensors
  - characteristics and networking, 132
  - communications, 134–135
  - IEEE-1451 standard
    - description, 132
    - modular architecture, 132–133
    - NCAP information model, 132
    - sections, 132
  - NCAP, 133–134
  - network management
    - basic encoding rules (BERs), 138–139
    - manager and, 136
    - SNMP, 136–138
  - plug-and-play (PNP) capability
    - advantages, 136
    - node requirements, 135
  - smart transducer interface module, 134
  - standardized reference, integration, 139
  - TEDS, *see* Transducer electronic data sheet
- Interacting
  - multi loop and
    - cascaded loops, 242–243
    - forward loops, 243–244
    - loop, 240–241
    - synchronised loops, 241–242
- Interactive network data collection, 200–201
- INTERBUS®, 349
- Interface message processor (IMP), 466
- Interfacing
  - RTDs, 340
  - sensor, 339–341
  - strain gauges load cells, 340–341
  - thermocouples, 339–340
  - transducer, 339–341
- Interference
  - antenna, 865
  - in band, 865
  - out of band, 865
- International Electrotechnical Commission (IEC)
  - FF physical layer, 878
  - IEC61158, 582
  - risk parameters, 873
  - SILs levels, 872
- International society of automation (ISA), 342, 345, 347, 350
- International Standard Organization (ISO)
  - corrigendum and guides, 153
  - ISO11898, 582
  - obtaining, 154
  - process industry and automation, 152–153
  - structure
    - committees and groups, 153
    - draft agreement, 154
    - international electrotechnical commission (IEC), 154
    - phases, 153–154
    - principles, 153
  - technical reports, 153
- International standards, 582
- International Telecommunications Union-Telecommunications Standards Sector (ITU-T), 494
- Internet
  - adaptation
    - industrial Ethernet development, 282
    - scale economy, 282
  - ARPANET, 275
  - automation
    - business enterprise systems networking, 276–277
    - DCS and PLCs, 276
    - device level networking, 277, 278
    - digital computers, 276
    - ERP systems, 277
    - LAN system architecture, DCS systems, 277
  - client-server paradigm, 275
  - convergence, 278–281
  - COTS software, 495
  - cyber security, 495–504
  - definition, 275, 484
  - evolution
    - ARPNET, PRNET and SATNET, 485
    - browser, 485–486
    - forms, web document, 487
    - IP, network layer, 486
    - models, 485–486
    - TCP/IP protocol architecture, 485
    - WWW, 487
  - feedback control
    - packet switched network, 279–280
    - remote process, 280
  - fundamentals
    - ARPANET and TCP software, 484–485
    - computer resources, 484
    - protocols, 484
  - governmental use, 495
  - harmonization, 282
  - host configuration
    - logical and physical addresses, 487–488
    - packet switches and routers, 488
    - TCP and hop, 488
  - interconnecting business
    - ERP system, 280
    - plant control networks, 280
  - interoperability
    - bus wars, 282
    - OLE, 282
  - IP addressing, 490–492
  - IPv6 and IPSec, 279
  - ISPs, 493
  - manufacturing, 280
  - messages, 275
  - monitoring
    - feedback control, 280
    - laboratory instrumentation software, 280
  - network traffic, 275
  - OSI network model, 275–276
  - process control, 276–277
  - real-time interactive services, 492–493
  - RFID technology, 280–281
  - routing protocols, 492
  - security
    - client-server architecture, 278
    - gateways and data encryption, 278
    - guaranteed delivery, 275–276
    - IP based protocols, 278
    - and performance, 281
  - smart sensor standards, 282
  - standardization, 494–495
  - supervisory control, 280
  - TCP/IP protocols, 275
  - TCP/IP protocol suite, 488–490
  - technology, 282
  - VPN, 278
  - wireless networks, 281–282
- Internet calibration
  - Fluke 4950 multifunctional instrument, 147
  - requirements, 147–148
  - services (iCals), 148
  - traceability, 147
- Internet Control Message Protocol (ICMP), 488
- Internet Group Management Protocol (IGMP), 489
- Internet key exchange (IKE)
  - phase 1, 521
  - phase 1.5, 521
  - phase 2, 521
- Internet packet exchange (IPX), 488
- Internet protocol (IP) addressing
  - classes, 490
  - class-oriented *vs.* classless, 490
  - DDNS, 492
  - DNS, 491–492
  - IPsec, 491
  - IPv6, 491
- Internet protocol (IP) networks, 565
  - electrical properties, cabling, 476
  - variations, 476
- Internet protocol security (IPsec)
  - data
    - integrity, 520
    - protection, 519–520
  - features, 520
  - protocols data confidentiality, 520

- Internet service providers (ISPs)
  - connection-oriented and connectionless service, 493
  - international, national and local, 493
- Internet standardization
  - forums, 494
  - regulatory agencies, 494–495
  - RFCs, 494
  - standards organizations, 494–495
- Internet technology, 196–197
- Internetworking Protocol version 6 (IPv6)
  - advantages, 490
  - transition strategies, 491
- Intranet
  - company, 476
- Intrinsically safety (IS) barrier, 706, 711, 712
- Intrinsic safety (IS), 595
  - barrier, 590, 595
- Intrusion prevention systems, 501
- Intrusion protection system, 572
- Inventory
  - kanban, 763
  - on-wheels, 770
- Inverters, 922, 924
- Inverters, grid connected, 922, 923
- I/O integration
  - core cables, 634
  - device, types, 633, 634
  - standard GSD files, 634
- IPSec, *see* IP Security
- IP Security (IPSec)
  - network layer protocol, 491
  - VPN over internet/public networks, 491
- IPv4, *see* IP version 4
- IPv6, *see* Internetworking Protocol version 6
- IPv6 and IPSec, 279
- IP version 4 (IPv4), 486, 490–491
- IPX, *see* Internet packet exchange
- IRT, *see* Incident Response Team; Incident response team; Isochronous real-time
- IS, *see* Intrinsic safety
- ISA, *see* International society of automation
- ISA-100, 350
- ISA batch standards, 807
- ISO, *see* International Standard Organization
- Isochronous real-time (IRT) communication, 631, 632
- ISO/IEC 7498, 348
- ISO 27k standards, 677–678
- Isolation
  - optical, 338–339
  - signal conditioners, 338
- ISO 31000:2009 Risk Management Principles and Guidelines, 682
- ISPs, *see* Internet service providers
- IT security, 34
- ITU-T, *see* International Telecommunications Union-Telecommunications Standards Sector

J

- JIS, *see* Just-in-sequence
- JIT, *see* Just-in-time
- Just-in-sequence (JIS)
  - deliveries, suppliers' park, 772
  - manufacturers, 773
  - on-wheels inventory, 770
- Just-in-time (JIT), 395
  - holistic logistics strategy, 770
  - JIS suppliers' park, 772
  - schedules/signals, 771

K

- Kaikaku, 763, 764
- Kaizen, 763
- Kanban, 391, 402
- Key performance indicators (KPIs)
  - batch cycle time, 192
  - production, 193
  - return on investment (ROI), 192
  - scope, measurement and target, 193
- Key variables
  - accuracy, 73
  - availability, 79
  - estimation, 74
  - measured variables, 73
  - observability, 81, 82
  - reliability and availability, 73
- Knocked down
  - complete (CKD), 764
  - medium (MKD), 764
  - semi (SKD), 764

L

- LabVIEW Program, 360–361
  - controller
    - anti-delay, 428
    - feedforward, 426–427
    - 3-input–3-output, 429–430
    - MIMO, 430, 431
    - Robust, 428–430
- LAN, *see* Local area network
- Language
  - machine, 303–304
  - programming, 303
- LAN topology
  - Bus and Ring, 470
  - Ethernet, 470–471
  - loop system, 470
- Laplace transform, 316, 317
- Latency, 351–352
- Lateral drilling, 435
- Layer
  - application
    - FAS, 602–603
    - FDA agent, 606
    - FMS, 603
  - data link, 600–602, 606
  - network, 599, 606
  - physical (PhL), 600, 606
  - transport, 599, 606
- Layered protocol configuration, 470
- Layer of protection analysis (LOPA), 873
- Layers of protection, 730
- Layout design
  - factory arrangements, 399
  - hypothesis manufacturing system, 400
  - items determination, 400–401
- Lead-acid batteries, 924
- Leak detection, *see* Bias detection
- Leased lines
  - dial up lines, 287–288
  - point to multipoint, 287
  - point to point, 287
- LEOS, *see* Low earth orbit satellites
- Leveraging MES, 693
- LF, *see* Liquid fraction
- Library of analysis functions, 221–222
- Licensed radio
  - repeaters, 293
  - topology, 294
  - wireless telemetry, 284
- Light sources
  - LEDs, 535–536
  - VCSEL, 536
- Linearity, 332, 333
- Linear time invariant (LTI), 314–317, 321, 322, 327
- Line system design
  - cell production, 397
  - CNC, 397
  - FMS simulation model, 397, 398
  - transfer
    - with buffer function, 396, 397
    - and FMS, 396–397
    - simulation model, 396–397
    - stagnation, 396, 397
    - without buffer function, 396
  - types, 395
- Liquid fraction (LF), 781
- Literature on calibration
  - books, 146
  - calibration services, 146
  - institutions, 146
  - manufacturers, 146
  - organizations, 146
- Lithium ion batteries, 924
- Load cells, 340–341
- Local area network (LAN), 201, 517
  - architecture, 467–472
  - components, 467
  - data highways, 276
  - defined, 466
  - standardization, 467
  - system architecture, DCS, 277
  - use and technologies, 466–467
- Logic
  - development, 102–106
  - normal exceptional, 184–185
  - simulation, 104
  - tests, 104
- Logical link control (LLC), 655, 656, 658
- Logic diagrams, 102
- Logic solver, 101, 103
- Lonworks
  - application
    - binding, 663
    - foreign frame, 663
    - functions, 662
    - network variables, 662–663
    - protocol data unit, 662
  - data link, 661
  - description, 660

- network, 661–662
- physical, 661
- presentation, 662
- transport, 662

Low earth orbit satellites (LEOS), 298
Lower explosive limit (LEL), 708, 712
LTI, *see* Linear time invariant

M

- 4–20 mA
  - 4–20 mA/HART, 60–61
- MAA, *see* Message access agent
- MAC, *see* Media access control
- Machine language
  - definition, 303
  - execution, 304
- MAC layer, *see* Medium access control layer
- 4–20mA current loop
  - receiver, 589–590
  - three wire connection, 590
  - transmitter, 589–590
- Magneto-optic (MO), 537–538
- Maintenance
  - compliance, 754
  - predictive, 754
  - preventive, 754
  - reliability data, 754
  - task descriptions, 754
- Maintenance coordinator
  - production, role, 217
- Maintenance managed as business, 752, 755
- Maintenance management
  - cost control, 746
  - inventory, 746
  - key performance indicators, 746
  - planning, 746
  - preventive, 746
  - safety handle, 746
  - schedule, 746
  - systems, 746
  - work order, 746
- Maintenance repair operations (MRO)
  - inventory accuracy, 753
  - materials management, 753–754
- MA model, *see* Moving average model
- MAN, *see* Metropolitan area network
- Management
  - maintenance, 691
  - quality, 691
- Management, intelligent sensor networks
  - basic encoding rules
    - data types and identifiers, 138
    - PDU lower layers, 139
    - SNMP message format, 138
  - manager, 136
  - SNMP protocol
    - architecture, 137
    - ASN.1, 138
    - features, 137
    - management information bases (MIBs), 137
    - “managers” and “agent”, 136
    - messages, manager and agents, 137
    - monitoring and control devices, 138
    - object identifiers (OID), 137–138
- Managing VPNs
  - auto-managed networks and SD, 523
  - global companies, 523
  - medium size companies, 523
  - small companies, 523
- Manipulated variable (MV), 84, 204, 213, 272
- Manuals
  - maintenance, 102
  - operations, 102
- Manufacturing
  - automobile, 762–779
  - management, 762–779
  - simulation
    - design phase, 393–401
    - distributed technologies, 404
- Manufacturing enterprise solutions association (MESA)
  - and MES functions, 690–691
- Manufacturing execution systems (MES)
  - benefits, 693–696
  - collaborative, 696–697
  - definitions
    - decision efficiency, 689, 690
    - MESA, 689
    - plant operations, 690
  - importance
    - business drivers, supply chain and production relationship, 694, 695
    - “demand-driven” models, 694
    - organization values, 695–696
  - integration, organizational activities, 691–693
  - key features, 697
  - MESA and functions, 690–691
  - objectives, 689
  - software support, 693
  - values, 695–696
- Manufacturing message specification (MMS), 166, 581
- Manufacturing modes, 11
- Manufacturing system emulation
  - implementation phase, 401–404
- Manufacturing system engineering
  - process, 391–393
  - simulation and emulation, 404
- Manufacturing systems
  - emulation, implementation phase
    - classification, 401
    - 3D-CAD information, 402, 403
    - engineering process, 401
    - functions, 402
    - ORiN architecture, 402, 403
    - procedures, 402–404
    - system architecture, 402, 404
  - engineering process
    - emulation, 392, 393
    - phases, 391
    - procedure, 393, 394
    - simulation, 392, 393
  - simulation, design phase
    - layout, 399–401
    - line system, 395–398
    - material and information flow, 394, 395
    - process, work and production management, 395
    - structures and processes specifications, 393–394
    - transfer system, 398–399
- Manufacturing system simulation
  - design phase
    - layout, 399–401
    - line system, 395–398
    - transfer system, 398–399
  - JIT, 395
- MAS, *see* Multiple address system
- Master
  - primary, 595
  - secondary, 595
- Master production schedule (MPS), 764, 767
- Master slave
  - configuration, 288
  - integrity poll, 286
  - polling
    - duplex, 285
    - improvements, 285
    - integrity poll, 286
    - point-to-multipoint, 288
    - report by exception, 285–286
  - report by exception, 285–286
- Material
  - bill, 750
  - critical spares, 754
  - inventory, 753
  - management, MRO, 753
  - parts kiting, 753
  - parts requisition, 753–754
  - reorder notification process, 754
  - warranty, 754
- Material of construction (MOC), 798
- Matlab toolbox
  - Fuzzy rule interpolation (FRI), 845
  - sparse fuzzy model identification (SFMI), 845
- Maximum delay time, 432
- MBC, *see* Model-based control
- MBONE, *see* Multicast Backbone
- MC-OXC, *see* Multigranularity optical cross-connect
- MCT, *see* Minimum cycle time
- Mean time to failure (MTTF), 737
- Measurement assurance planning (MAP), 146
- Measurement test (MT)
  - defined, 372–373
  - linear transformation, 373
- Measures against cyber attacks, 498–499
- Media access control (MAC)
  - IEEE 802.11, 480–481
  - layers, 480
  - spoofing, 482
- Media access methods
  - bus arbitration, 52–53
  - master slave, 52
  - time division, 53
  - token passing, 53
- Medium access control (MAC) layer, 556, 637, 644, 645, 649
- Medium access efficiency (η_{MA}), 584
- Medium earth orbit satellites (MEOS), 298
- Membership
  - functions, 267–271
  - value, 267–271

- Membership structure
  - correspondent, 152, 153
  - full, 152, 153
  - non-voting, 152
  - subscriber, 152
  - voting, 152, 154
- Memory
  - cache
    - component, 304
    - computer hierarchy, 307
    - definition, 303
    - in microprocessors and microcontrollers, 307
    - registers, 307
  - subsystem
    - L1 and L2 cache, 307
    - speed, capacity, and cost, 306
- Memory organisation, 602
- MEMs, *see* Microelectromechanical systems
- MEOS, *see* Medium earth orbit satellites
- MES, *see* Manufacturing execution systems
- MES functions
  - data collection, 691
  - document control, 690–691
  - operations scheduling, 691
  - performance analysis, 691
  - process management, 691
  - production units, 691
  - product tracking, 691
  - resource allocation, 690
- Message access agent (MAA), 490
- Message specification, *see* Fieldbus message specification (FMS)
- Message Transfer Agent (MTA), 490
- Messaging
  - MMS, 581
- MES software, 693
- Meteorological mast, 942, 944, 947
- Meter reading
  - filed sites, 860–861
  - protocols, 861
- Metropolitan area network (MAN), 4
  - applications, 472–473
  - regional resource sharing, 472
  - *vs.* WAN, 467
- MFA advantages and suitability, 417
- MFA-based auto-driller, 435
- MFA control applications
  - building automation, 434–435
  - drilling equipment, 435
  - Ethylene, 432–434
  - gas mixing, 434
  - pH, 432–434
- MFA control for building automation, 434–435
- MFA control for gas mixing system, 434
- 2×2 MFA controller, 420, 421
- 3×3 MFA controller, 421, 429, 430
- MFA controller architecture, 418
- MFA controller gain, 418, 422, 423, 430
- MFA control software, *see* Model-free adaptive control software
- MFA control software for open-PLC, 437
- 2×2 MFA control system, 420–421, 431
- 3×3 MFA control system, 429–430
- MFA control toolbox for MATLAB® software, 431–432
- MFA control toolset
  - configuration in LabVIEW, 426–427
  - feedforward, 426–427
  - labVIEW, 426–431
- MFA for drilling equipment control, 435
- MFA for pH Control, 432–434
- MFA methodology
  - combined intelligence, 435–436
- MFA optimizer, 416, 419
- MFA Ph controller
  - configuration in Cybocon, 424
  - gain-scheduling method, 424
- MFA XRT
  - configuration, 425–426
  - controller, 425–426
- Microcomputer, *see* Digital technology
- Microcontroller, *see* Digital technology
- Microelectromechanical systems (MEMs), 537
- Microprocessor
  - CPU
    - architecture, 304
    - embedded system, 306
    - IC/microchip, 304
    - L1 and L2 cache memory, 307
    - manufacturers and products, 305
    - universal computing machine, 306
  - dual core, 304
  - multi core, 304, 308
- Middleware, 387
- Migration methods
  - cold, 702
  - green, 702
  - hot, 702
  - vendor change, 702
  - warm, 702
- Milling
  - DCS, 850–851
  - flotation
    - control, 852–854
    - instrumentation, 851–852
  - grinding
    - control, 851
    - instrumentation, 851
- MIME, *see* Multipurpose Internet Mail Extension
- MIMO MFA controller
  - application guide, 430, 431
  - LabVIEW, 429–430
- MIMO MFA control system, 432
- MIMO process, *see* Multiple input multiple output process
- Mine
  - automation, 833–839
  - dewatering, 834–835
  - hoists, 833–834
  - inventory tracking, 832–833
  - operating centre, 832
  - performance, 832
  - power consumption, 833
  - system, 836–837
  - ventilation, 835–836
  - visualization, 832–833
  - waste handling, 834
- Mine design
  - geologic model, 848
  - open pit mining, 848–849
  - underground mining, 849–850
- Mineral processing
  - AI, 841–845
  - automation, 847
  - communication systems, 848
  - first-order kinetic model, 848
  - fuzzy logic, 840–846
  - Kalman filter, 848
  - methods, 847
  - separation equipment, 840
  - technologies, 847–848
- Mine wide
  - backfill, 837–838
  - communication, 821–822
  - fuel, 836–837
  - infrastructure, 821–822
  - SCADA, 822
  - strategy, 821
  - technology, 821
- Mine-wide SCADA system
  - automation and applications
    - backfill plant, 837–838
    - dewatering, 834–835
    - fuel transfer system, 836–837
    - hoists, 833–834
    - ore/waste handling system, 834
    - underground electrical substation, 838–839
    - ventilation, 835–836
  - design criteria
    - IEC-61131-3 specification, 824–825
    - integrated and motor control centers, 823–824
    - remote administration, 825–828
  - plant visualisation standards
    - alarms, 829–832
    - high performance, 828–829
    - HMI, 828
  - technology
    - communications system infrastructure, 821–822
    - HMI, 822
    - hoistman, 822
    - Nickel Rim South Mine, 821
    - self-regulating controls, 822
  - visualisation
    - levels, 832, 833
    - operations centre (OC), 832–833
- Minimum cycle time (MCT)
  - defined, 583
- Minimum delay time, 432
- Mining
  - automation
    - grinding and flotation, 850–851
    - open pits, 848–849
    - process and program, 847
    - systems, 855
    - underground, 849
  - computer, *see* Computer control in mining
  - control, *see* Computer control in mining
  - equipment
    - LHD, 855
    - mobile, 848
    - positioning, 850
    - telemining, 849

- methods
  - described, 847
  - geologic model, 848
  - mill charge measurement, 851
  - MPC and FTC, 852
  - open pit, 848–849
  - underground, 849–850
  - X-ray fluorescence, 852
- process
  - automation, 847, 855–856
  - control, 848, 849, 854
  - mineral and material, 848

Misconfigured
- firmware, 866
- packets, 866
- radios, 866

MMS, *see* Manufacturing message specification
MO, *see* Magneto-optic
MOC, *see* Material of construction
MODBUS, 344–347
- architecture, 63
- ASCII, 344–345
- buffering, 289
- characteristics, 63
- codes, 345
- ControlNet
  - description, 63–64
  - physical layer, 64
- description, 63
- Ethernet
  - "Ethernet Fieldbus", 64–65
  - information content and response times, 65
  - PROFINET, 64
- Ethernet port, 287
- frame, 345–346
- master-slave polling, 285
- radio modem, 289
- RTU, 344
- RTU and ASCII, 286
- TCP/IP, 345
- transaction, 345–346
- wireless, 65

MODBUS-RTPS, 349
Modbus TCP
- adaptation
  - MBAP header, 639
  - PDU and ADU, 638–639
  - TCP/IP models communications, 639
- application layer
  - data model, 640
  - FCs, 639–640
  - ISO/OSI model, 639
- architecture, 638, 639
- network, 638, 639
- RTUs, 638
- transport layer, 638–639

MODBUS TCPI/P, 875
Model
- data, 784–785
- parameters, 784–786
- physical, 784–786

Model-based adaptive control, 436
Model-based control (MBC), 415, 417, 420, 421, 424, 436, 437
Model-free adaptive (MFA) control software
- advantages, 417
- applications, 432–435
- approach, 417
- definition, 416–417
- issues, 437
- LabVIEW, 426–431
- MATLAB, 431–432
- methodology, 435–436
- multivariable control system, 419–426
- RRC, 415
- single-loop control system, 417–419
- suitability, 417

Modelling
- approach, 881–883
- standards, 881, 883–885

Model predictive control
- cost benefit analysis, 191
- optimization, 191

Model predictive control (MPC), 415, 416, 856
- algorithm, 210
- batch processes, 190–191
- condition metrics, 211–213
- constraints
  - limits, 210, 211
  - management, 211
- cost benefit analysis, 191
- dynamic model, 210
- elements, 210
- limits, CV
  - activation, 211
  - violation, 212
- optimization, 191
- performance
  - metrics, 210–211
  - monitoring, 210

Modems, 289
Modular design, 806
Modulation
- cross phase, 535
- four wave mixing (FWM), 535
- Raman scattering, 535
- self phase, 535

Modulators and demodulators, 320–321
Monitoring and control
- application, 932–934
- architecture, 932–934
- PLC, 932–934
- SCADA, 931–932
- strategy, 931–934
- system, 931–933

Monitor safeguards, 685–686
Monotonicity, 332
MOSPF, *see* Multicast Open Shortest Path First
Moving average (MA) model, 260
MPC, *see* Model predictive control
MPLS, *see* Multi protocol label switching
MPS, *see* Master production schedule
MRO, *see* Maintenance repair operations
MT, *see* Measurement test
MTA, *see* Message Transfer Agent
MTTF, *see* Mean time to failure
Multicast Backbone (MBONE), 492
Multicasting communication, 466
- MOSPF, CBT and MBONE, 492
- RSVP, 492

Multicast Open Shortest Path First (MOSPF), 492
Multichannel systems, 335–336
Multi function I/O systems
- analog output, 336
- counters, 337
- digital, 336–337
- timers, 337

Multigranularity optical cross-connect (MG-OXC)
- BTW, 548, 549
- FXC, 548, 549

Multi-loop and interacting systems
- cascade, 242–243
- feedforward, 243–244
- interacting, 240–241
- synchronized, 241–242

Multi-loop controller, 5, 8
Multimode, 945
Multiple address system (MAS)
- frequencies, data telemetery, 289
- network, 286
- point-to-multipoint, 290

Multiple gross error identification
- commercial software, 373
- data reconciliation accuracy, 376
- equivalency, 374–375
- nonlinear steady-state data reconciliation, 376–377
- objective functions, 375–376
- serial elimination and UBET, 374
- size estimation, 375
- uncertainties, 374

Multiple input multiple output (MIMO) process, 419, 420
Multiple protocols, 348–350
Multiplexers
- analog inputs, 335, 336
- and multichannel systems, 335–336
- parallel A/D-per-channel DAQ system, 335–336

Multiplexers/demultiplexers (MUX/ DEMUX)
- DWDM, 538
- MZI, 539
- WDM, 538–539

Multiplexing, 296
Multi protocol label switching (MPLS), 475
Multipurpose Internet Mail Extension (MIME), 489
Multivariable controllers, 244
Multivariable control system
- Cybocon control software, 421–424
- 2-input–2-output, 420–421
- MFA XRT, 425–426
- software products, 421

Multivariate statistics, 234
MUX/DEMUX, *see* Multiplexers/ demultiplexers

N

NAMUR Recommendation NE97, 618–619
National Electrical Code (NEC)
- division and zone classification system, hazardous area, 708–710

National Fire Protection Agency (NFPA)
  hazardous area classifications, 708, 713, 714
National Institute of Standards and Technology (NIST), 685
NEC, *see* National Electrical Code
NetWare operating system
  described, 471–472
  remote procedure, 472
Net-wide data exchange
  digital factors, 69
  product attributes, 69
  step, 69
  XML, 69–70
Network access protection (NAP)
  architecture, 568–570
  IP, 565
  models, 565–568
Network capable application processor (NCAP)
  blocks, 134
  STIM, 133
Network classes
  LAN, 466–467
  MAN and WAN, 467
Network components, 101, 103
  ex-protection concept, 59
  function, 58, 59
  plant management level, 58
Network configuration
  application layer, 647–648
  protocol, 647–648
  topology, 647
Network design
  factors, 630
Network Information Center (NIC), 488, 495
Network integration, 6
  availability, 34
  integrity, 34
  quality, 34
  scalability, 34
  security, 34
  standards, 34
Network layers, 469
  data routing, 53
  Internet Protocol (IP), 53–54
  wireless systems, 54
Network management
  COM DTM revolution, 612
  HSE, 606–607
  redundancy, 604, 607
Network protocol
  data link layer, 46
  SNMP devices, 136
  UDP, 275
Network requirements
  central servers, 44
  fieldbus and management level data characteristics, 45
  I/O, 44
  standardization, 45
Networks, 351–363
  application, 933, 937
  architecture, 937
  authentication, 510–512
  authorization, 512–513
  connectivity, 103, 868
  data success, 864–865
  encryption, 506–509
  information channels, 528
  logic solvers, 101, 103
  media, 101, 103
  presentation tier, 933, 937
  protocols, 527–528
  routing, 864–866
  security
    cryptography, 506
    devices, 513–515
    encryption, 506–509
  servers, 933, 937
  services, 527–528
  signal strength, 864
  software, 937
  switches, 103
  threats, 509–510
  tickle success, 864, 865
  transport, 528
  types, 527
Network security, 58
  aims, 674
  awareness
    Code of Ethics, 675
    education, 674–675
    organizational culture, 675–676
  employees and elements, 688
  management
    areas, 677
    described, defense in depth, 677
    description, 677
    information classification and ownership, 679–680
    information security management, 677–678
    operational level, 681
    personnel practices, 680–681
    policy, 678–679
  organizations, 687
  prevention mechanisms, 688
  risk analysis
    description, 681
    impact and risk exposure, 683–684
    management objectives, 683
    management process, 681–682
    monitor safeguards, threat levels and risks, 685–686
    safeguards implementation and manage residual risk, 684–685
    threat, risk and vulnerability definitions, 681
    threats and vulnerabilities, 682–683
    types, threats, 681
  security incident handling, 686–687
Network security policy, 678–679
Network time protocol (NTP), 32
Network topologies
  mesh and tree, 51
  ring and bus, 51
  star topology, 51
  “tree” structure and “clusters”, 50
Network update time (NUT), 658–659
Neural fuzzy systems
  ANFIS, 846
  extraction/induction algorithms, 845
  intelligent computation, 845
  non-linear functions, 845
Neural network (NN), 243–244
  applications, 263
  concepts
    ANN, 256–259
    ARMA model, 260–262
    AR model, 260
    biological inspiration, 255–256
    conventional regression approaches, 262–263
    dynamic models, 260
    inverse mechanism, 261
    MA model, 260
    regression modeling and parallels, 262
    SISO process, 261–262
    transfer functions, 259–260
  process and automation
    applications, 263
    empirical model, 254
    model-free attribute, 254
    nonlinear dynamic process, 255
    regression, 262
    SISO process, 255
  quantitative technology, 438
  sequential analysis, 442
  sequential empirical optimization, 439–440
Neural network terminology
  model, 259–261
  moving average, 260
  nerve cells, 256–258
  neurons, 256–259
  sigmoidal, 257–259
Neutron
  detector
    APSD, 914, 915
    ex-core, 912–913
    life extension, 913–914
  life, 907, 908, 913–914
New control room
  component library, 410
  early design phase, 410
  equipment, 411
Next-generation network (NGN), 561
Next generation optical networks, 532
NFPA, *see* National Fire Protection Agency
NGN, *see* Next-generation network
NIC, *see* Network Information Center
Niche fieldbuses
  actuator sensor interface, 664–667
  controlnet
    application layer, 660
    data link layer, 658–659
    network and transport layers, 659–660
    physical layer, 658
    presentation layer, 660
  cyclic data exchange and acyclic transmission, 654
  devicenet
    application layer, 657
    data link layer, 655–657
    physicl layer, 654–655
  factory automation systems structure, 654, 655

- fieldbus communication profile, 654, 655
- Lonworks
  - application layer, 662–663
  - data link layer, 661
  - description, 660
  - network layer, 661–662
  - physical layer, 661
  - transport layer, 662
- Sercos, 667–669
- worldFIP, 663–664

NIST, *see* National Institute of Standards and Technology
NN, *see* Neural Network; Neural network
Noise, 423
Non-incendive, equipment type, 706
Non linear algorithms
- adaptive, 240
- Dahlin controller, 239
- derivative, 237
- error squared, 237
- filtering, 237
- integral squared, 238
- model free, 240
- PID, 237–239
- proportional, 237
- Smith predictor, 239
- standard, 237

Non-linearity index (NLI), 207
Non linear MFA controller
- configuration in Cybocon, 423–424
- input–output relationship, 423

Nonlinear steady-state data reconciliation
- application, software, 377
- process plants, 376

Normalisation, 271
North American hazardous area classification
- classes II and III, 709–710
- class I, 708–709

Nuclear
- control, *see* On-line monitoring (OLM), nuclear power plant
- detection, 903, 907, 908, 910, 916–917
- instrumentation, *see* Nuclear plant instrumentation and monitoring
- monitoring, *see* On-line monitoring (OLM), nuclear power plant
- performance, *see* On-line monitoring (OLM), nuclear power plant
- plant, *see* Nuclear plant instrumentation and monitoring
- pressure transmitter
  - on-line calibration monitoring, 911
  - response time testing, 910–911
  - sensing line blockages, 910
- response time
  - sensor, 909, 917
  - testing, pressure transmitters, 910–911
  - transmitter, 906
- sensing
  - line blockage detection, 910
  - system, 909

Nuclear plant instrumentation and monitoring
- global power demand and nuclear energy role
  - countries and electricity generation, 904
  - technologies implementation, 905
  - UAE and South Korea, 904–905
- license renewal, 903
- noise analysis techniques
  - advantage and application, 903
  - measured signal characteristics, 903–904
- OLM
  - benefits, 908
  - development and motivation, 908–910
  - fundamentals, 905–908
  - implementation, 910–914
  - systems, 914–917
- OLM technologies and R&D efforts, 903
- resources and software, 917

O

OADM, *see* Optical add-drop multiplexer
Object identifiers (OID), 137–139
Object linking and embedding (OLE), 282, 870
Object linking and embedding (OLE) for process control, 200, 201
Object process control (OPC), 870, 875, 876
Objects
- grouping, 608
- link, 608
- supporting, 608
- trend, 608

OBS, *see* Optical burst switching
OBS medium access, 556
OBS network core
- contention resolution, 556
- MAC layer, 556
- scheduling, 556

Obtaining standards
- information, 154
- websites, 154–155

OCTAVE process, *see* Operationally Critical Threat, Asset, and Vulnerability Evaluation process
Office IT, 571–573
Offshore Reliability Data (OREADA) handbook, 874
OFS, *see* Optical flow switching
Oil and gas
- availability, 870
- control
  - room design, 871–872
  - system, 872–876, 878–879
  - third-party packages, 876
- disclaimer, 879
- fire and gas detection system, 877
- foundation fieldbus, 877–878
- industry, 870, 872, 874
- instrumentation, 878
- PST, *see* Partial stroke test
- reliable
  - control system requirements, 876
  - FGS, 877
  - guaranteed, 872
  - plant instrumentation and control systems, 872
  - SIS and SIL, 872
- safe, 872–874
- SIS, *see* Safety instrumented system
- system architecture
  - block diagram, 870, 871
  - control room design, 870–872
  - DCS and FGS, 870
  - subsea network, 870, 871
- third-party packages, 876

Oil and gas well drilling, 435
Omni-directional
- antenna, 293
- cells, 296
- signal strength, 294
- transmission, 295

Online control, 786–789
Online estimation, 786–789
On-line monitoring (OLM), nuclear power plant
- benefits, 908, 909
- data acquisition system
  - described, 914, 915
  - design and requirements, 917
  - dynamic signal analysis, 915
  - flow and analysis, 916–917
  - signal conditioning module, 915–916
- development and motivation
  - I&C sensor evaluation, 909
  - noise analysis and sensor response time, 909
  - operating experience, 909–910
  - regulatory requirements, 908–909
- fundamentals
  - applications *vs.* sampling frequency, 906–907
  - I&C sensors, 907–908
  - process sensor output, 906
  - PWR, 905, 906
  - static and dynamic data analysis, 906, 907
- implementation
  - detection, sensing line blockages, 910
  - fluid flow monitoring, 912–913
  - neutron detectors, 913–914
  - pressure transmitters, 910–911
  - sensor, detector and transmitter, 910
  - temperature sensors, 911–912
- reports, 911, 915
- signal
  - conditioning module, 915–916
  - dynamic component, 906
  - ex-core neutron detectors and CETs, 913
  - pressure, 909, 910
- software, 914, 916, 917
- system, 914–917

OP, *see* Output
Open-loop, 415–416
Open-loop stable, 419, 430
Open pit mining
- GPS, 849
- linear programming and dispatchers, 848–849
- mobile equipment, 848

Open Shortest Path First (OSPF), 492
Open system implementation
- EDDL
  - definition, 611

    - EDD, 611
    - *vs.* FDT: FDI, 613
    - fieldbus foundation products, 611–612
  - field device tool/device type manager, 612–613
  - Foundation Fieldbus software support, 613–614
- Open system interconnection (OSI), 275, 276
- Open Systems Interconnection-Reference Model (OSI-RM)
  - configurations, layered protocol, 470, 471
  - data flow, 468, 469
  - definition, system, 467–468
  - frame reduction, 468
  - LAN topology and connectivity, 470–471
  - layers
    - entity and protocol, 468
    - physical and data link, 468–469
    - presentation and application, 469
    - SAP, physical layer, 468
  - NetWare, 471–472
  - protocols
    - defined, 469
    - functions, 469–470
- Operating system (OS)
  - definition, 303
  - modern microprocessor, 307
  - program execution, 306
- Operational amplifier, 318–319
- Operationally Critical Threat, Asset, and Vulnerability Evaluation (OCTAVE) process
  - CVE and BugTraq, 686
  - three-phased approach, 685–686
  - workshops uses and catalogs, 686
- Operation optimization
  - adjustment performance metric, 439
  - experience and trial-and-error, 438
  - objective, 439
  - performance index (PI), 438
  - process, 439
  - “regulatory control”, 439
  - scopes, 439
  - SEO, DEO and NN, 438
  - sequential empirical optimization
    - application, 444–449
    - data operation, 439
    - mathematical structure, 440–444
    - nature, 439–440
- Operation performance
  - availability, 704
  - control rooms, 704–705
  - redundancy, 704
- Operator console
  - control display, 22
- Operator intervention
  - count, 207
  - shift supervisor, 216
- Optical
  - communications, 525–526
  - networks, 525–532
- Optical add-drop multiplexer (OADM), 547
- Optical burst switching (OBS)
  - burst assembly, 554
  - network edge, 554
  - node, 553
  - signaling, 554–555
- Optical cross-connect (OXC)
  - AONs, 546, 548
  - OEO, 548–550
  - OOO node, 546
- Optical-electrical-optical (OEO) conversion
  - control packet, 554
  - multiplexing, 548
  - OOO nodes, 546
  - OPS router, 557
  - optical signal, 550
  - TDM switching and grooming, 549–550
- Optical fibers
  - attenuation, 533–534
  - dispersion, 534
  - loss, 533–534
  - nonlinearities, 534–535
  - scattering, 535
- Optical flow switching (OFS)
  - IP, 552–553
  - reverse reservation, 553
  - tell-and-go reservation, 553
- Optical packet switching (OPS)
  - ATM, 557–558
  - buffering, 559–560
  - optical correlator, 558
  - packet format, 557–558
  - unified contention resolution, 561
  - wavelength conversion, 560–561
- Optical receivers
  - APDs PIN diodes, 536
- Optical switches
  - TO, 537
  - AO, 537
  - EO, 537
  - MEMs, 537
  - MO, 537–538
- Optimal adjustment
  - operation optimization, 439
  - plastic forming, molding/large parts injection, 447
- Optimisation
  - enterprise-wide, 194–195
  - process plant, 194
  - synchronization, 195–196
- Orbit
  - geosynchronous earth orbit satellites (GEOS), 298
  - low earth orbit satellites (LEOS), 298
  - medium earth orbit satellites (MEOS), 298
- Order
  - bank, 766
  - delivery, 766–767
  - entry, 766
  - manufacturing, 766–767
  - scheduling, 766
  - sequencing, 766
- Order-to-delivery process, 766–767
- Organizational
  - recommendations
    - controls, 868
    - diagnostics, 867–868
    - network maintenance, 868
    - operational, 868
    - performance, 868
    - standards, 867
- Organizational activities
  - context information systems, 691, 692
  - functional hierarchy
    - ANSI/ISA-965 Part-1, 691, 692
    - levels, 692–693
  - integration, 691–693
  - MES, 691–693
- Organizational condition
  - automobile plant, 764
  - characteristics, lean production, 763
  - efficiency gap, 763
  - Kaikuku implementation, 764
  - kanban and kaizen, 763
  - mass production model, 762
  - World vehicle production, 763
  - “zero inventories” model, 764–765
- Orthogonal Frequency Division Multiplexing (OFDM) technology, 478
- OS, *see* Operating system
- OSI, *see* Open system interconnection
- OSI reference model
  - control and fieldbus protocols, 46–47
  - implementations, 45–46
  - layer, 45, 46
  - wireless networks, 47, 49
- OSI-RM, *see* Open Systems Interconnection-Reference Model
- OSI seven layer model
  - application, 593
  - data link, 592–593
  - network, 593
  - physical, 591–592
  - transport, 593
- OSPF, *see* Open Shortest Path First
- OTV, *see* Output tracking variable
- Output (OP), 415, 417–423, 428–432
  - analog, 93
  - discrete, 93
  - isolation, 93
  - module, 92–93
  - saturation, 207
  - scan, 94
  - status indicator, 93
- Output saturation, 207
- Output tracking variable (OTV), 421, 431

P

- Packet filters, 500
- Packet optical transport networks (P-OTNs)
  - CAPEX and OPEX, 561
  - Ethernet, 561, 562
  - Ethernet frame, 562–563
  - Ethernet technology, 561–562
  - MPLS, 561
  - PBB-TE network, 563
  - SONET, 561, 562
  - SONET/SDH, 561, 562
- Packet Radio, 289–290, 859
- PACs, *see* Programmable automation controllers
- PAN, *see* Personal area network
- Panels
  - bid packages, 102
  - control, creation, 104–106

    control panel vendor, 102
    local control, 106, 107
    Master display, 107–111
    RON EFSO display screens, 111, 112
    T2X EFSO display screen, 111, 113
    wiring diagrams, 102
Parameter estimation
    precision, 75–77
    repairable sensor networks, 79–80
    resource allocation, 77–78
Partial least squares (PLS), 72, 73, 80
Partial stroke
    test, 876–877
    valve, 876–877
Partial stroke test (PST)
    implementation, 877
    valve signature, 877
Passive components
    circulators, 541–542
    couplers, 541
    isolators, 541–542
    power splitters, 541
Passive filter, 322
PBB-TE, *see* Provider backbone bridge-traffic engineering
PCI Express bus, 353
PCI eXtensions for Instrumentation (PXI), 353
PCN, *see* Process control network
PCS, *see* Process control systems
PCT, *see* Private communications technology
PDA, *see* Personal digital assistant
PDUs, *see* Protocol data units
Peer authentication, 520
Peer to peer, 286, 288, 294
Performance
    access efficiency, 584
    coding efficiency, 583–584
    expected, 233
    indices, 232–233
    minimum cycle time, 583
    throughput, 583
    tuning parameters criteria, 233
Performance constraints, 72
Performance index (PI), 438
Performance measurement
    craft performance, 755
    customer service, 755
    downtime, 754–755
    process, 755
Performance monitoring, 252
    and condition-based maintenance, 214–217
    MPC, 210
Periodic signal, 314, 325
Peripheral component interconnect (PCI) bus, 353
Personal area network (PAN), 476
Personal digital assistant (PDA), 466–467, 476, 478, 482
Pharmaceutical
    automation, 803–808
    industry, 803–804
    software, *see* Pharmaceutical automation software
Pharmaceutical automation software
    batch operations
        bioreactors, 806
        centrifugation and chromatographic separations, 806–807
        ISA standard, 807
        management software, 807
        sequential function charts, 807
    classification, 804
    design and implementation, 803
    electronic records and signatures, 807–808
    engineering practice
        common documents, 806
        GAMP V-model, 805
        HMIs, 806
        modular design, 806
        PLCs and DCSs, 806
        time stamping, 806
    GAMP guide, 803
    government and quality requirement, 803
    HVAC system automation, 808
    types and implementation, PA, 804
    validation, 804
    value chain, 804
Pharmaceutical industry
    needs, 803–804
    quality, 803
    regulations, 803
    responsibility, 803
    validation, 804
Phase modulation, 320
pH break point A, 424
pH break point B, 424
pH control, 416, 417, 424, 432–434
    system, 432
PHE, *see* Plate heat exchanger
Phishing and pharming, 498
Photonic slot
    copying, 550
    merging, 550–551
    routing (PSR), 550–552
    switching, 550
Photonic slot routing (PSR), 550–552
Photosynthesis, 919–920
Photovoltaic (PV)
    collector, 920–924
    control, 922–924
    grid connected, 926–927
Photovoltaic solar cells, 921
pH titration curve, 424
Physical layer, 468
    junction box, 600
    spurs, 600
    trunks, 600
Physical layer redundancy, 584
PI, *see* Performance index
PID, *see* Proportional-integral-derivative
PID controller, 415, 418, 421, 424, 425, 428, 429, 436, 437
P&IDs, *see* Piping and instrumentation diagrams
Piping and instrumentation diagrams (P&IDs)
    panel wiring, 102
PKI, *see* Public key infrastructure
Planning and scheduling
    coordination, operations, 753
    craft utilization, 753
    description, 752–753
    planned work, 753
    repairs, 753
    spare parts status, 753
    work schedules, 753
Plant
    automobile
        constraints, 767
        disturbances, 775
        high-volume mass production model, 762
        kaikuku project implementation, 764
        logistics providers, 770
        order-to-delivery process, 766
        phases, 764
        planning process, 767
        process, 765
    evolution, 828
    HMI, 828
    management, 763, 769–770
    performance, 828–829
Plant area, 5–7, 25–27, 30, 32
Plant laboratory, 8
Plant layout, 5–6
Plant location, 5, 6
Plant maintenance, 8
Plant management
    energy, 43
    inventory, 43
    maintenance, 42–43
    SCADA systems, 41–42
    software tools, 43
Plant operators
    control room, 7, 8
    definition, 5
    job, 6–7
    operator I, 7
    operator II, 7
    operator III, 7
    production targets, 6
Plant optimization
    controller algorithms
        characterizers, 237
        filters, 237
        non-linear, 237–240
    multi-loop and interacting systems
        cascade, 242–243
        feedforward, 243–244
        interacting, 240–241
        synchronized, 241–242
    organization impact, tuning
        recirculation, 229
        units, parallel, 229
    plan
        benefits, 230
        budget and workforce, 229–230
        performance, 229
        sustaining results, 229
    process
        loop tuning, 231–232
        performance indices, 232–237

- rationale
  - "conductor", 228
  - control objectives, 228
- software tools
  - auto-tune, pre-tune and self-tune, 251–252
  - closed-loop *vs.* open-loop tuning, 245–251
  - packages, 244–245
- variability
  - dryer, 231
  - drying process, 230–231

Plant organisation
- hierarchy
  - control, 7
  - control system, 7
  - operations, 7
  - organizations, 6, 7
  - physical plant, 7
- process areas, 6

Plant structure
- enclosed structure, 6
- open air, 6

Plants using communication networks
- automation system, 578, 579

Plant-wide controller
- autonomous data collection and analysis software
  - OPC and LAN, 201
  - simple network architecture, 201, 202
- business performance, 213–214
- control performance
  - condition and diagnostic metrics, 206–210
  - condition-based maintenance, 214–217
  - definition, 203
  - metrics, 203–206
- enterprise-wide
  - analyze, 221–222
  - contextualize, 220–221
  - measure, 218–220
  - orchestrate, 222, 224–227
- interactive network data collection and analysis software, 200–201
- MPC, 210–213
- offline data acquisition and analysis equipment, 200
- oscillations, 200, 201
- process automation, 200
- response speed, 200, 201
- usage, 200, 201

PLAs, *see* Programmable logic arrays

Plate heat exchanger (PHE), 799

PLC instructions
- automation
  - objective, 98
  - process, description, 98
  - steps, execution, 98
  - water distribution plant, 98, 99
- counters, up and down, 97, 98
- timers, 95–97

PLC programming
- block standards
- enterprise integration
- function block diagram, 95
- instruction list, 95
- ladder, 94–98
- languages
- sequential function chart, 95
- standards

PLCs, *see* Programmable logic controllers

PLC trends
- DeviceNet, 98
- Ethernet, 99
- integrated architecture, 99, 100

Plug-and-play (PnP)
- intelligent sensor capability, 135–136

PM/PdM, *see* Preventive and predictive maintenance

P-NET, 348, 349

Point to multipoint, 287, 288, 294

Point-to-point communication, 466

Poles and zeros, 316

Policy based access control
- condition and action, 567
- uses, 567–568

Polling
- master-slave, 285
- modem, 288
- point-to-multipoint systems, 285
- report by exception, 285–286
- response times, 290

Pop-ups, 104–106

P-OTNs, *see* Packet optical transport networks

Pouch filling, 799–800

Power
- demand, 904–905
- global, 904–905
- nuclear, 910–917

Power industry
- cyber security, 887–889
- equipment, 888
- failures, 888
- safety, 888
- threats, 888

Powerlink cycle
- asynchronous phase, 646
- idle, 646
- isochronous phase, 645–646
- poll request, 646
- timeout, 646

Power network
- communication, 880–884
- profile, 883–884, 886–887, 891–893
- security, 887–896
- system, 880–884

Power network security
- communications
  - IEC 61850, 881
  - IEC TC 57 modeling standards, 881
  - modeling, 881–883
  - parts, 880–881
  - profile mapping, 883–884
  - SAS, 881
- cyber
  - requirement, 889–890
  - threats, 887–888
- DER, *see* Distributed energy resources
- electric power utilities (EPUs), 880
- IED access control
  - IEC 61850, 888–889
  - PMI based, 898
  - substation system, 898–899
- vulnerability, 889
- web serviced-based monitoring and control
  - communication model and security requirements, 894–895
  - designing principles, 895–896
  - design mechanism, 896
  - mechanism implementation, 896
  - security token, 895
- wind power plant
  - communication profile mapping, 886–887
  - information exchange model, 885–886
  - information model, 884–885

Precision
- estimates threshold, 78, 81

Precision of estimates, 367

Precision upgrade
- constraints, 76
- monitoring, 76
- optimization, 76
- uncertainty, 75–76

Prediction, 263

Predictive maintenance (PdM)
- captures reliability data, 754
- change process, 754
- lubrication services, 754
- schedule, 754
- task descriptions, 754

Presentation layer, 469

Pressure transmitter
- calibration, 906, 907, 909, 911
- monitoring, 906, 907, 911

Pressurization
- equipment, 712

Pressurized water reactor (PWR) plant
- primary loop, 905
- RTDs and CETs, 911–912
- sensing line blockages, 910
- thermocouples, 912–913

Preventive and predictive maintenance (PM/PdM)
- change process, 754
- "Class A" installation, 750
- CMMS
  - reliability data, 754
  - selection process, 750
- compliance, 754
- long range schedule, 754
- lubrication services, 754
- task descriptions, 754

Preventive maintenance (PM), 750, 754

Prioritization
- control performance monitoring software, 217
- mechanism, problems, 224

Private communications technology (PCT), 518

Private key encryption
- advantage, 506
- block ciphers, 507–508
- building block, 506–507
- secret key, 506
- stream ciphers, 507

Probability of failure on demand (PFD), 872, 874

- Process
  - acting type, 422, 430
  - automation (PA)
    - common engineering documents, 806
    - pharmaceutical industry, 803
    - software, 804
  - delay time, 424, 428, 436
  - linearity factor, 423–424
  - sign, 427
  - software, 803–808
  - software classification, 804
  - static gain, 427, 430, 436
  - time constant, 422, 424, 428, 430, 436
  - variation, 417, 424
- Process cells, 180–181
- Process control
  - business
    - benefits, 214
    - level objectives, 213
  - business level objectives, 213
  - engineer, 216
  - OPC data communication standard, 200
- Process control device connectivity, 36
- Process control network (PCN)
  - alarms, 32–33
  - diagnostics, 32
  - messages, 32
  - redundancy, 32
  - time synchronisation, 32
- Process control software, 385–386
- Process control systems (PCS)
  - integrated, 855–856
  - underground mining, 850
- Processes
  - batch, 90
  - composite, 90
  - continuous, 90
- Processes safety
  - applications, 718
  - certifications, 716
  - critical condition management
    - addressing, 729
    - ASM consortium, 731
    - CCM functions, 730–731
    - environmental impact, 729
    - factors, 730
    - negative impact, 729–730
    - off-the-shelf CCM packages, 732
    - protection layers, 730
  - culture
    - corporate commitment and responsibilities, 733–734
    - description, 732
    - equipment, practice and reporting, 734
    - management role, 733
    - organization, 732–733
    - programs and procedures, 734
    - training and worker empowerment, 734
  - duplex system, 718
  - electromechanical and solid state relays, 717–718
  - hazard and risk analysis
    - ALARP, 724
    - certifications, 727
    - definition, 724
    - fire and gas monitoring, 726
    - graph, 725–726
    - IEC 61508 and 61511, 724
    - integrity levels determination methods, 725
    - ISA technical report, 726–727
  - integrity levels (SIL), 720
  - lifecycle management
    - ABB Eutech and ACM, 723
    - analysis phase, 721
    - dyadem, exida and primatech, 723
    - functions, 722
    - implementation problems, 722
    - maintenance phase, 721
    - realization phase, 721
    - SIS-tech, 723
    - solution providers, 722
  - management responsibilities, 723–724
  - quad system, 719
  - risk
    - definition, 716–717
    - driving forces, 718
    - factors, 718
    - reduction, 717
  - selection
    - conventional control systems, 732
    - criteria, 732
    - protection requirements, 732
  - standards
    - ANSI/ISA-84, 720
    - IEC 61508, 719
    - IEC 61511, 719–720
  - TMR system, 7188
  - trends
    - automated monitoring and field device testing, 728
    - control system, 728
    - flexibility and scalability, 728–729
    - function blocks, 729
    - I/O-related health functions, 728
    - SIS failure, 728
- Process field bus (PROFIBUS) networks
  - decentralized periphery (DP)
    - application profiles, 618–619
    - cyclic data communication, 617–618
    - DPM1 and DPM2, 616, 617
    - master–slave/slave–slave protocol, 618
    - process control, 618
    - PROFIBUS DPV1 network configuration, 622–623
    - slaves, 617
    - system standards, 617
    - version DPV1 architecture, 619–620
    - version DPV1 media access, 620–622
  - FMS, 616
  - process automation (PA)
    - architecture, 624–626
    - configuration network, 628–629
    - couplers and links segment, 624
    - cycle times, 631
    - device configuration, 629–630
    - FISCO model, 626–627
    - media access, 627–628
    - multi-drop barrier, 627
    - network design, 630
    - principle technical data, 624
    - *vs.* PROFIBUS DP system, 624
    - telegram length, 630–631
  - PROFINET, 631–634
- Process field network (PROFINET)
  - communication stack, 631, 632
  - component-based automation, 632–633
  - implementation, 631
  - industrial applications, 631
  - I/O integration, 633–634
  - SCADA system, 631
- Process networks *vs.* office networks, 34–36, 38
- Process optimisation
  - benefits, 230
  - budget, 229–230
  - plan, 229–230
  - plant organisation, 228–229
  - rationale, 228
  - workforce, 229–230
- Process optimisation tools
  - analysis, 234
  - interacting loops, 233
  - monitoring, 234
- Process optimization methods
  - planning models, 231–232
  - tuning, 231–232
- Process plants
  - control system classification
    - batch and continuous mode, 11
    - batch process, 17
    - continuous processes, 14–15
    - discrete and process manufacturing, 10
    - fed-batch processes, 17–19
    - industrial production, 10
    - integrating response, 16
    - modes, systems, and controls, 11
    - profile control, 19–20
    - safety systems, 12–14
    - self-regulating processes, 15–16
  - DCS, *see* Distributed control systems
  - laboratories, 8
  - maintenance, 8
  - networks integration
    - design principles, 34
    - equipment packages, 36
    - field instruments, 36
    - IT security, 34
    - office environment, 34
    - plant environment, 34–36
    - process control device connectivity, 36
    - wireless networks and devices, 36
  - operators, 6–8
  - organization, 6
  - performance requirements
    - anti-aliasing filtering, 28–29
    - control execution rates, 28
    - IO processing delays, 27, 28
  - structure, 6
- Process response, 261–263
- Process safety management
  - responsibilities, 723–724
- Process variables (PV), 416–418, 421, 423, 425, 427–432, 590
- Procurement
  - direct delivery, 771
  - dispatch centre, 771

    distribution centre (DC), 771
    variant, 770–773
Procurement systems
    and suppliers, network configuration, 767–769
    suppliers structure, 769–770
    variants, 770–773
Product
    safety, 190
    traceability, 190
Production
    assembly
        automobile modules/system, 764
        characteristics, lean production, 763
        disturbance, 772
        ground plan, BMW plant, 773
        JIS, suppliers' park, 772
        JIT delivery, supplier's park, 772
        line, 771
        mass production model, 762
        operations, 764–765
        order sequencing, 766
        resource, 767
        variants, 764
    automobile
        assembly information, 772
        cost, 762
    body
        assembly variants, 764
        car parts, 779
        ground plan, BMW plant, 773
        just-in-sequence delivery, 772
        manufacturing, 766
        optical scans and bar code, 771
        order-to-deliver process, 766
        sequenced order, 765
    control, 773–776
    management, 763, 769–770
    paint shop
        assembly line, 771
        manufacturing, 766
        phase, 764
    planning, 765–773
    system
        automobile plant, 773
        disturbances, 774
        and economy, 765
        high stability, 764
        POIN, 775
        precursors, 763
        resource, 767
Production control
    bar codes/GS1 code, 773
    control process, 775
    database structure, 774
    disturbance management, 774
    disturbances, automobile plant, 775
    indicators, 775–776
    MPS execution, 774–775
Production indicators
    cycle, 775
    POIN, 775–776
    sequence disturbance, 776
Production planning
    "3DayCar" program, 765
    definition, scheduling, 767
    MPS, 767
    order-to-delivery process, 766–767
    policies, 765
    procurement and suppliers, 767–769
    structure, suppliers, 769–770
    variants, procurement system, 770–773
Profibus, 349, 858
    architecture, 61
    Profibus dp, 61–62
    Profibus pa, 61–62
Profibus DP
    application profiles, 618–619
    DPV1 version
        architecture, 619–620
        media access, 620–622
    Master class 1, 616
    Master class 2, 617
    PROFIBUS DPV1 network configuration, 622–623
    slaves, 617
    system standards, 617
Profibus PA
    architecture, 624–626
    configuration
        device, 629–630
        network, 628–629
    cycle times, 631
    FISCO model, 626–627
    media access, 627–628
    multi-drop barrier, 627
    network design, 630
    telegram length, 630–631
PROFIdrive, 619
PROFINET, *see* Process field network
PROFIsafe
    application
        PROFIBUS layers, 619
        safety systems, 618
Programmable automation, 159–160
Programmable automation controllers (PACs), 145
    and PLC, 183
    automotive industry, 809–810
Programmable logic arrays (PLAs)
    architecture, 310
    AND and OR array, programmable, 309
Programmable logic controllers (PLCs), 415, 416, 421, 437, 858, 868, 869
    automotive industry, 809–810
    "boxes", 56
    components, 91
    CPU
        indicators, 93–94
        "scanning", 93
        scan time, 94
        specifications, 94
    and DCSs, 804, 806
    definition, 91
    Device Net, 98
    emulator and operation panel emulator, 402
    Ethernet, 99
    evolution, automation
        electromechanical (relay) control, 90–91
        hardwired electronic control, 91
    hard-wired relay arrays, 55
    industrial computers, 276
    input modules
        analog, 92
        discrete, 92
        functions, 91
        sinking and sourcing type, 92
        specifications, 92
        wiring, 93
    integrated architecture, 99, 100
    LANs, 276, 277
    memory, 94
    modern automation, 803
    output modules
        discrete and analog, 93
        functions, 93
        wiring, 93
    and PAC, 183
    power supply, 94
    processes, 90
    programming
        devices, 94
        FBD, 95
        instruction list, 95
        ladder diagram, 94–98
        language standard, 176–177
        SFC, 95
        structured text, 95
    soft wiring system., 403–404
    stand-alone, architecture, 55
Programming languages, 303
    assembly, 389
    definition, 389
    high level, 389
    lower level, 389
    machine codes, 389
Programming robots
    Fanuc's KAREL language, 166–167
    language levels and features, 166
    ON-LINE and OFF-LINE, 166
    servo-robots, procedure, 167
Programming software, 388
Program scan, 94
Project application specification
    acceptance criteria, 187–188
    functional design, 187
    requirements, 187
Proportional-integral-derivative (PID), 8, 11, 14
Protocol, 861, 862, 869
Protocol bridge, 869
Protocol data units (PDUs), 638–639
Protocols
    interface device, 285
    interfacing, LAN layer, 469–470
    layer
        configurations, 470
        defined, 468
    telemetry, 286–287
    time-sensitive data, 284
Provider backbone bridges (PBBs)
    ESP, 563
    UNI, 563
Provider backbone bridge-traffic engineering (PBB-TE), 562, 563
Pseudo-random-binary sequence (PRBS) test, 245, 247

PSR, *see* Photonic slot routing
Public key encryption
    data encryption, 508
    ECC, 508
    elliptic curve cryptography, 508
    infrastructure, 508–509
    recent developments, 509
    RSA, 508
    trapdoor functions, 508
Public key infrastructure (PKI), 508–509, 511
Purging
    definition, 712
    equipment, 706
    type X, 712, 713
    type Y, 712–713
    type Z, 713
Purging equipment, 706
PV, *see* Photovoltaic; Process variables
PV collector systems, 922–924
PV lower bound, 429
PV upper bound, 429
PXI Express, 353

Q

QoS, *see* Quality-of-service
Quality check, 798
Quality-of-service (QoS), 553, 562
Quantifying, 330
Quench water pH, 432–434

R

Radio
    application, 860
    head end, 860
    location communication, 859–860
    network, 863–864, 866–867
    packet, 859
    traffic, 862–863
Radio-frequency identification (RFID) technology
    tags
        active and passive, 280–281
        bar codes, 280
Radio modems
    intelligent, 289
    simple, 289
Radio network
    concerns, 863–864
    issues, 863–864
Radio ownership, 866–867
Radio repeaters
    forward, 293–294
    non-buffering, 293
Radio telemetry
    frequencies, 289
    history, 288–289
    licensed bands
        928/950 and 932/941 MHz multiple address system, 290–291
        frequency coordinators, 290
        960 MHz point-to-point, 291
        800 MHz trunking and mobile radio, 290
        splinter frequencies and offset channels, 290
        UHF 450–470 MHz, 290
        UHF/VHF channels, 290
        VHF 150–174 MHz, 290
    modems, 289–290
    Morse code, 288
    packet radio, 289–290
    repeaters, 293–294
    spread spectrum
        DSSS, 292
        FHSS, 292
        2.4–2.4835 GHz, 292
        5.725–5.85 GHz, 293
        902–928 MHz, 292
        modulation technique, 291
        noise, integral component, 291
    topologies, 294
    unlicensed bands, 291
Radio traffic
    data flow, 863
    exception report, 863
Random signal, 314
RARP, *see* Reverse Address Resolution Protocol
Rate of penetration, 435
Real-time interactive services
    applications, 493
    interactive audio/video, 493
    protocols, 493
    streaming stored audio/video and RTSP, 493
Received signal strength indication (RSSI), 864
Recipes
    dynamic, 191
    general, 174–175, 188
    management, 185
    master, 174, 175
    site, 174–175, 188
    unit, 185
Reconciliation software, 379
Reconfigurable optical add–drop multiplexer (ROADM), 547
Redundancy
    absence, 72
    advanced architectures, 743
    bias and leak detection, 370
    classification, 72
    DCS, 25
    described, 365
    dual architecture
        controller architecture, 741
        DC power supplies, 740, 741
        electronic controller architecture, 741
        failure analysis, 741, 742
    and failure considerations
        physical medium, 584
        station, 584–585
        transmission, 585
    fault-tolerance capabilities, 743, 744
    input/output cards, 24
    PCN, 32–33
    precision upgrade, 75
    residual precision, 80
    triple architecture
        majority voting circuit, 742
        triple controller architecture, 742
    voting architecture, 743
Redundant information, 830–831
Register
    level 1 cache memory (L1 cache), 307
    RISC microprocessor, 304
Regression, 255, 259, 262, 263
Regression modelling, 262
Regular regulatory control (RRC), 415
Relative accuracy, 335
Reliability, 197–198
    automation system, 736
    availability, 738
    constant failure rate, 737–738
    MTTF, 737
Reliability improvement
    common cause, 740–742
    diagnostics, 739–730
    high strength, 739
    industrial control systems, 739, 740
    Markov model, 741
    redundancy, 739
Reliability of variables, 73, 78, 79
Reliable sensor network
    bilinear networks, 78
    cost-based representation, 78–79
Remanufacturing
    inspection, 777
    recover
        ferrous and nonferrous metals, 777
        goal, 776
    recoverability
        ELV directive, 777
        EU regulation, 776
    recycling, 777
    reuse, 777, 778
Remote
    administration, 825–828
    capabilities, 825–828
    configuration, 825–828
    cost, 826–827
    diagnostics, 825–828
    hardware, 825, 827
Remote access, 518
Remote control
    speed and repeatability, 284
Remote terminal units (RTUs), 638, 859–864
    buffering, 289
    master-slave polling, 285
    repeater, configuration, 293
Renewable energy processes
    biological life cycle, 819–820
    control software, PV, 926–928
    energy free homes, 920–924
    global energy consumption, 929, 930
    RFC, 928–929
    solar-hydrogen system, 928
    storing solar energy, 924
        charge controllers, 926
        generated electricity, batteries, 924–926
Renewable energy software, 919, 920

Repairable sensor networks
  service availability, 79
  service reliability, 79
Report by exception, 285–286
Report on exception, 863
Request for Comments (RFCs), 494
Resistance temperature detectors (RTDs), 340
  PWR plants, 911–912
Resistor, 318, 320, 322, 323
Resolution, 332
Resource allocation, 77–78
Resource hierarchy, 567
Resource Reservation Protocol (RSVP), 492
Respiration, 919, 920
Return on investment (ROI), 188, 192
Reverse acting, 419, 422, 430
Reverse Address Resolution Protocol (RARP), 490
Reverse logistics, 776–779
Reversible fuel cell (RFC)
  control, 929
  proton electrolyte membrane (PEM) design, 928–929
RFC, *see* Reversible fuel cell
RFCs, *see* Request for Comments
RFID technology, *see* Radio-frequency identification technology
Ring-laser-gyro (RLG) systems
  test-bed surveying unit, 854
  underground mining, 850
RIP, *see* Routing Information Protocol
Risk
  analysis, *see* Risk analysis, network security
  evaluation, 682
  exposure, 683–684
  governance, 682
  management, *see* Risk management
  residual risk, 684–685
  response, 682
  safeguards, 684–686
  threats, 681
  treatment, 682
Risk analysis, network security
  description, 681
  impact and risk exposure
    bar chart, 684
    calculation formula, 683–684
    manual procedures, 683
    solution investment strategy, 683
    Symantec use, 683–684
  management objectives, 683
  management process
    applications and data storage, 681
    general activities, 681, 682
    IEEE Risk Management model, 681, 682
    ISACA, 682
    RISK IT framework processes, 682
  monitor safeguards, threat levels and risks
    OCTAVE process, 685–686
    SANS Top 20, 686
  safeguards implementation and manage residual risk
    Cyber Security Operations Center, 684
    effectiveness and costs, mitigation strategy, 685
    knowledge, 685
    network intrusions, NIST, 685
  threat, risk and vulnerability definitions, 681
  threats and vulnerabilities
    Australian Defense Security Directorate's information security manual, 682–683
    Organization's networked environment, 682
    penetration testers, 683
    quantitative measure, threat occurrence, 683
    rating approach, 683
  types, threats, 681
Risk assessment
  control system, 874
  facilities, 874
  matrix example, 874, 875
Risk management
  measure impact, 683–684
  objectives vulnerabilities, 682–683
Risk reduction, 716–717
ROADM, *see* Reconfigurable optical add–drop multiplexer
Robotics
  industrial applications, 160–162
  justification, 160, 162–163
Robot programming languages
  procedure, 167
Robots
  characteristics, 161, 163
  implementations
    development, 161
    installation, 162
    mock-up, 161–162
    planning, 161
  industrial applications
    breakdown, 160–161
    characteristics *vs.* process selection, 161, 163
    supply, 161, 162
  work-cell controls and industrial programming, 164–167
Robust MFA controller
  LabVIEW, 428–430
Robust sensor networks
  availability, 80
  error detectability, 80, 81
  precision, 80–81
  resilience, 80, 81
Role based access control (RBAC), 567, 899
Roles and responsibilities
  control performance management work process, 216
  disposition options, 217
  plant manager, 216
  production and process engineer, 216
  supervisors, 216
  technician, E&I, 216
  unit operators, 216
Routing, 299
  decision, 865–866
  domain, 865
  photonic slot, 550–552
  wavelength assignment, 555
Routing Information Protocol (RIP), 492
Routing protocols
  BGP, 492
  OSPF, 492
  RIP, 492
  unicast communications, 492
RRC, *see* Regular regulatory control
RS-232, 354
RSA
  vs. ECC, 508
  public key cryptosystem, 508
  security, 509
  trapdoor functions, 508
RSSI, *see* Received signal strength indication
RSVP, *see* Resource Reservation Protocol
RTDs, *see* Resistance temperature detectors
RTUs, *see* Remote terminal units

S

SA, *see* Security association
Safety
  certification, 727
  culture, 732–734
  management, 720–724
  organisational culture, 732–733
  overall, 728
  rules, 716–734
  standards, 719–720
  system selection, 732
  trends, 727–729
Safety instrumented system (SIS), 12, 13
  implementation
    2oo2, 876
    2oo3, 876
Safety integrity levels (SIL), 12, 13, 65–66
  analysis, 725
  determining, 725
  fire and gas monitoring, 726
  risk graph, 725–726
Safety lifecycle
  analysis, 721
  implementation, 722
  maintenance, 721
  management, 720–723
  ongoing functions, 722
  realization, 721
  solution provider, 722
Safety standards
  general safety, 719
  integrity levels, 719–720
  process industries, 716, 719
Safety system, 11–14
Sample interval, 422, 423, 430
Sample size, 373
Sampling operation, 326
SANS, *see* SysAdmin, Audit, Network, Security
SAP, *see* Service access point

- Satellites
  - network, 299
  - orbit, 298
- Satellite telemetry
  - communication bands, 299
  - definition, 297
  - networks
    - protocols, 299
    - routing, 299
    - topology, 299
  - NOCs and TDMA, 297
  - satellite orbits, 298
  - technology
    - centrifugal force, 297
    - Kepler's law, 297–298
    - period, defined, 297
- SCADA, *see* Supervisory control and data acquisition; Supervisory control data acquisition
- SCADA components
  - digital inputs, 102
  - digital outputs, 102
  - field I/O, 102–103
  - logic solvers, 103
  - networks and network components, 103
  - relay outputs, 103
- SCADA configuration
  - compilation and codes, 104
  - CPU connection and codes download, 104
  - hardware, 103
  - I/O allocation, 103
  - logic development, 103–104
  - logic simulations and pretests, 104
  - point loading, 103
- SCADA, SNMP, 574
- SCADA software, 103–104
- Scheduling
  - estimated, 556
  - explicit, 556
- Scheduling and execution, 222
- Schemes
  - building blocks, 104, 105
  - colour, 105
  - home screen, 104, 105
  - navigation, 105
- Scope types, 701–702
- SCTP, *see* Stream Control Transmission Protocol
- SD, *see* Service delivery
- SDH, *see* Synchronous digital hierarchy
- SECROS III
  - Ethernet cables, 668
  - IP, 669
  - operation principle, 669
  - topologies, 669
- Secure personnel
  - hiring, 680
  - ongoing employment, 680
  - termination additional measures, 680–681
- Secure socket layer (SSL)
  - PCT, 518
  - reverse proxy, 519
  - site-to-site VPN, 519
  - transport layer security (TLS), 511–512, 516
  - VPN tunnels, 519
  - websites identification, 518–519
- Securing devices
  - cryptography, 506
  - data encryption, 513
  - full disk encryption
    - comparison, tools, 514–515
    - Linux, 515
- Security
  - authentication, 25
  - awareness
    - Code of Ethics, 675
    - education, 674–675
    - organizational culture, 675–676
  - management
    - areas, 677
    - described, defense in depth, 677
    - description, 677
    - information classification and ownership, 679–680
    - international standards, 677–678
    - operational level, 681
    - personnel practices, 680
    - policy, 678–679
  - plant area security, 25
  - user access, 25
- Security and performance
  - cyberspace, 281
- Security association (SA), 521
- Security auditing, 502
- Security awareness, *see* Security
- Security incident handling
  - countermeasures, 687
  - description, 686–687
  - intrusion detection, 687
  - intrusion prevention, 687
  - log analysis, 687
  - preparation and notification, 687
  - recovery and follow-up, 687
  - response, 687
  - system integrity alerts, 687
  - tools, 687
- Security mechanism
  - design, 896
  - implementation, 896
  - security agent, 896
- Security standardization, WLAN, 482
- SEI, *see* Software Engineering Institute
- Selection of control system
  - DCS, 875, 876
  - life cycle, 875–876
  - plant, 874
  - trouble shooting and analyzing, 875
- Self calibration, 130, 147
- Self regulating process, 15–16
- Self regulation control
  - optimization, 822
- Semiconductor optical amplifiers (SOAs), 540–541
- Sensing and reconstruction, 408
- Sensor actuators, 132, 135, 136
- Sensor interfacing, 53, 335, 339–341
- Sensor networks
  - automation, 84–85
  - controllers, 84–85
  - control variables (CV), 84
  - cost optimal accurate, 74–75
  - economic value optimal, 81–82
  - IEEE 1451 standard, 132–133
  - intelligent, management
    - basic encoding rules, 138–139
    - manager, 136
    - SNMP protocol, 136–138
  - manipulated variables (MV), 84, 85
  - PnP achievement, 136
  - reliable, 78–79
  - repairable, 79–80
  - robust, 80–81
- Sensors
  - array systems, 323
  - charge, 313
  - current, 313
  - resistive, 313
  - and transducers
    - classification, 313
    - signals, low amplitudes, 319
  - voltage, 313
- SEO, *see* Sequential empirical optimization
- SEO analytics, 443–444
- SEO cycle
  - learn, 440
  - optimize, 440
  - update, 440
- Sequence
  - bypass, 114–115
  - communication failure, 116
  - EFSO sequence, 111–112
  - HMI screens, bypass sequence, 115–116, 124–129
  - HMI screens, EFSO, 112–114, 116–123
- Sequential empirical optimization (SEO)
  - application, 444–448
  - data operation, 439
  - mathematical structure
    - advantage, 442
    - definition, 442
    - ideal solution, perfect knowledge, 441–442
    - operation optimization, I/O process, 441
    - optimization plan, 440
    - performance, 442–443
  - nature, 439–440
- Sequential function charts (SFC), 23
- SERCOS, 349
  - communication profile, 667
  - datalink layer, 668
  - physical layer, 667–668
  - SERCOS I, 667–668
  - SERCOS II, 667–668
  - SERCOS III, 668–669
  - versions, 667
- Serial elimination, 374
- Serial interface, 875
- Service access point (SAP)
  - physical layer, 468
  - socket, 477
- Service delivery (SD), 523
- Service factor (SF)
  - definitions, 206
  - factored total clock time, 206
  - and SF_E, 206–207
- Service provider, 275
- Session layer, 469

Setpoint (SP), 417–421, 423, 431
  open loop, 15
Setpoint activity, 209–210
Settling time, 332, 333
Shingles, solar, 921
Siemens SIMATIC IT
  historian structural display, 456, 458
  individual components data flow, 455, 458
SIF instruments, 572
Signal conditioning, 342
  amplification, 338
  circuitry, 337, 338
  filtering, 338
  isolation, 338–339
  sensor and transducer interfacing
    industrial requirements, 339
    resistance temperature detectors (RTDs), 340
    strain gages and load cells, 340–341
    thermocouple instrumentation, 339–340
    Wheatstone bridge circuit, 340
Signal conversion, 342
Signal energy, 315
Signalling
  centralized, 554, 555
  distributed, 554, 555
Signal multiplexing, 529
Signal nonlinearity
  detection, 207
  non-linearity index (NLI), 207
  oscillating controller error, 208
  static friction, 208
  valve stiction metric, 208–209
    limit cycle, 209
    PV vs. OP ellipse, 209, 210
    static friction, 208
Signal power, 315
Signals
  analogue
    continuous/discrete time signals, 314–315
    differential equation representation, 316
    energy and power, 315
    frequency response, 317
    impulse response, 315
    Laplace and Fourier transform, 316–317
    magnitude and phase representation, 317
    periodic/aperiodic signals, 314
    random and symmetric signals, 314
    signal-to-noise ratio, 315
    systems, 313–314
  aperiodic, 314
  continuous, 314–315
  digital, 323–325
  discrete time, 314–315
  energy, 315
  periodic, 314, 325
  power signal-to-noise ratio, 315
  processing
    analog signals, 313–321
    anolog filters, 321–323
    digital (DSP), 323–329
    random, 314
    symmetric, 314
Signal sampling, 326
Signal-to-Noise Ratio (SNR), 315
Signal transmission
  analogue, 342–343
  digital, 344–350
  protocols, 348–350
  standards, 347–348
SIL, *see* Safety integrity levels
SIL study
  fail availability and probability, demand, 872
  methodology, 874
  personnel safety determination-risk graph, 873
  target levels, 873
SIL verification, 874
Simple Network Management Protocol (SNMP), 46, 54, 490, 632
  basic encoding rules, 138–139
  event monitoring, 137
  information exchange, 137
  protocol data unit (PDU) data types, 138
  protocol, intelligent sensors, 136–138
  topology, 137
Simple Network Time Protocol (SNTP), 46, 54
Simplex mode, 284–286
Simulation
  hardware, 788–789
  software, 788–789
  WinSit software, 789
Simulink, 431, 432
Single-input-single-output (SISO) process, 255, 418–419
Single loop control system
  adaptive capability, 419
  algorithm, 418–419
  architecture, 418
  requirements, 419
  SISO MFA controller, 418
Single mode, 945
SISO MFA
  configuration in Cybocon, 422–423
  controller, 417, 418, 421, 422, 431
  control system, 417–418
SISO process, *see* Single-input-single-output process
Site change management, 879
Site-to-site VPN, 519, 520
Size codes, battery, 924, 925
Smart sensors standards, 282
Smart transducer interface
  IEEE standard, 132
  STIM, 133–135
Smart transducer interface module (STIM)
  logical structure, 134
  NCAP, 133–134
Smart transducers
  IEEE standard, 132
  interface module, 134
SMDS, *see* Switched multi-megabit data service
SNF, *see* Solids non fat
SNMP, *see* Simple Network Management Protocol
SNMP message
  format, 138, 139
  packet, 138, 139
  rules, 138–139
SNR, *see* Signal-to-Noise Ratio
SOAs, *see* Semiconductor optical amplifiers
Socket, *see* Client-server model
Softkey, 427
Soft sensors, 254
Software, 356–363
  characteristics, 386
  definition, 303, 385
  microcontroller, 304
  renewable energy, 919, 920
  store, retrieve, analyze and visualize data, 308
Software architecture
  application, 388
  programming, 388
  system, 388
Software characteristics
  database, 386
  documentation, 386
  message processing, 386
  model, 386
  moving data, 386
  object, 386
  program control, 386
  simulation, 386
  tools real-time, 386
  user interface, 386
Software design and implementation, 390
Software development tools, 390
Software Engineering Institute (SEI), 385
Software execution, 388
Software fundamentals
  architecture, 388
  characteristics, 386
  companies, 385
  definition, 385
  design and implementation, 390
  licenses, 389–390
  operation
    execution, 388
    library, 388
    machine language, 387–388
    types, computer, 387
  patents, 390
  process control and automation, 385–386
  programming languages
    BASIC, 389
    C language, 389
    computer program, 388
    definition, 389
    high-and low-level, 389
  quality and reliability, 389
  software engineering institute (SEI), 385
  tools, 386–387, 390
Software library, 388
Software licenses, 389–390
Software patents, 390
Software quality, 389
Software reliability, 389
Software standards, 389–390
  internet engineering task force (IETF), 155
  types, 155–157

Software support
  dataflow and usage, 693
  leveraging MES, 693
Software tools
  assemblers, 386–387
  compiler, 387
  debuggers, 387
  editors, 387
  interpreters, 387
  linkers, 387
  loaders, 387
  optimization tools, 244–245
Solar cells, photovoltaic, 921
Solar collectors
  grid connected PV, 926
  RFC, 928
Solar electricity storage, 924–926
Solar energy
  batteries, 924–926, 929
  battery charge, 921–922, 926
  storing, 924–926
Solar energy storage, 924–926
Solar hot water
  differential temperature switch (ΔTS), 921, 922
  indirect automatically controlled, 921, 923
  operation and installation, 921
Solar hydrogen, 920, 928
Solar shingles, 921
Solenoid valve (SV), 13
Solids non fat (SNF), 799
SONET, *see* Synchronous optical network
SP, *see* Setpoint
Specialized mobile radio, 290
Splinter channel
  frequencies, data telemetry, 289
  telemetry, 290
Splitters, 541
Spread spectrum
  DSSS, 292
  FHSS, 292–293
SQC/SPC, *see* Statistical quality/process control
SQL injection, *see* Structured query language injection
SSL, *see* Secure socket layer
Stacking, 562, 563
Standardization
  European, 581–582
  International, 582
  organizations process, 581
Standard organizations
  branches, American National Standards Institute, 151
  links, 152
  national and international, 151
  preparation process, stages, 152
  world, 150, 151
Standards
  control, automation and networks, 155, 156
  de-facto, 150
  de-jure, 150
  description, 813–814
  development
    ISO, 152–154
    organizations, 152
  fundamental physical, 150
  ladder logic approach, 814
  obtaining
    information, 154
    websites, 154–155
  organizations
    branches, American National Standards Institute, 151
    links, 152
    national and international, 151
    preparation process, stages, 152
    world, 150, 151
  preparation preliminary works, 152
  published/paper, 150, 155
  software
    closed and open, 156
    complexity, 156
    examples, 156, 157
  tools, 814
  using
    advantages, 155
    measurement and metrology, 155
  working procedure, 152
Statistical quality/process control (SQC/SPC), 415
Steady state linear data reconciliation
  material balance, 367
  practical challenges
    direct and indirect methods, 370
    dynamic model, 369
    high and slow sampling rates, processes, 369
    pseudo steady state, 369
    selection, boundaries, 370
    software users, 369
    tank hold-up measurements, 368–369
    variance–covariance matrix, 369–370
  precision, estimators, 367
Steel thixoforming
  automation, 794–795
  control, 787–788
  estimation, 787
  online, 786–789
  process, 785–786
  production, 794–795
Stochastic and random bus access, 53
Storage
  solar electricity, 924–926
  solar energy, 924–926
Store and forward repeater, 293–294
Strain gages, 340–341
Stream Control Transmission Protocol (SCTP), 489
Structured query language (SQL) injection, 510
Structure of plant
  multiple, 181
  parallel, 181
  single, 181
Substation automation system (SAS), 881
Substations
  access control, 900–901
  access security, 900–901
  automation, 900–901
  control, 944–946
  operation sequence, 900–901
  structure, 944
  virtual access view, 900
Substation system
  access control system
    architecture, 900
    functional modeling, 900
    operation sequence, 900–901
    virtual access, 900
  privilege delegation
    action, 899
    model, 898–899
    RBAC, 899
    target access policy, 899
Successive approximation converter, 334
Successive Approximation Register (SAR), 334
Supervisory control and data acquisition (SCADA)
  alarm log display screen, 111, 114
  auxiliary HMI display screen, 111
  components, 102–103
  configuration and software, 103–104
  data historian system, storage, 454
  description, 101
  engineering work stations, requirements, 106
  hardware, 101–107
  historical log, 111, 115
  HMI
    development, 105–106
    essentials, 101–102
    hardware, 104
    software, 104–105
  I/O allocations, 103
  master HMI display panel operation, 107–111
  master terminal unit (MTU), 57
  object link embedding (OLE), 58
  operation sequence
    bypass, 114–115
    communication failure, 116
    EFSO sequence, 111–112
    HMI screens, bypass sequence, 115–116, 124–129
    HMI screens, EFSO, 112–114, 116–123
  point loading, 103
  remote terminal unit (RTU), 57
  software, 42
  system definition, 106–107
  wind farms
    communication protocols, 947–948
    condition monitoring, 948–949
    data maintenance, 948
    platforms, 947
    portfolio systems, 949
Supervisory control data acquisition (SCADA), 862–863
Suppliers
  full service, 770
  hierarchy, 770
  house design, 770
  management, 770
  network, 769
  synchronous, 769
  tier 1, 770
  tier 2, 770

Supplies
  JIS, 770, 772
Supply chain
  distribution intensive, 192
  manufacturing intensive, 193
  optimising, 193–194
Switch architecture
  interface, 558, 559
  switching matrix, 558–559
Switched-capacitor (SC) filters, 323
Switched multi-megabit data service (SMDS), 475
Symbol coding efficiency(η_{SC}), 583–584
Symmetric signal, 314
Synchronization, 352
Synchronous digital hierarchy (SDH), 475
Synchronous optical network (SONET), 475
SysAdmin, Audit, Network, Security (SANS)
  description, 679
  SANS top 20, 686
System architecture, 9, 20
System availability, 704
System emulation
  manufacturing, 401–404
System management
  address assignment, 603
  clock distribution, 603
  function block scheduling, 603
  tag server, 603–604
System redundancy, 704
Systems
  control, 308
  information, 308
  reconfigurable, 308–309
System safety certification, 727
System selection criteria, 198–199
System simulation
  manufacturing
    layout design, 399–401
    line design, 395–399
    specifications, 394
    transfer design, 398–399
System software
  architecture, 388
  operating system, 387
  quality and reliability, 389
  real-time, 386
System timing, 343, 347
System timing controller, 335, 336

T

Tagging, 562
TCnet, 349
TCP, *see* Transmission Control Protocol; Transmission control protocol
TCP/IP, *see* Transmission Control Protocol/Internet Protocol
TCP/IP systems, *see* Industrial Ethernet
TDMA, *see* Time Division Multiple Access; Time division multiple access
TDMA principle, *see* Time division multiple access principle
TDM switching, 549–550
Technical
  guides, 153
  products, 153
  specifications, 153
  technical corrigendum, 153
Technical advisory
  committees, 153
  groups (TAGs), 153
TEDS, *see* Transducer electronic data sheet
Telegram length, 623, 630–631
Telemetry
  applications, 858–859
  control, 868–869
  integration, 862–863
  management, 858–869
  SCADA, 862–863
Telemetry and networks
  communication mode, 284–285
  master-slave polling, 285–286
  peer-to-peer communication, 286
  protocols
    Ethernet port, 287
    mediums, 287
    Modbus and DNP3, 285
    small data blocks, 286
    time-sensitive data, 284
  topology, 285
  types
    data acquisition, 284
    remote control, 284
Telemetry medium
  cellular networks, 295–297
  radios, 288–294
  satellites, 297–299
  telephones, 287–288
Telemetry systems
  bandwidth, 284
  cellular
    channels and clusters, 295–296
    digital cellular data, 296–297
    multiplexing, 296
    topology, 297
  definition, 284
  industrial sources, 284
  and networks
    communication mode, 284–285
    master-slave polling, 285–286
    peer-to-peer communication, 286
    protocols, 286–287
    topologies, 285
    types, 284
  radio
    licensed bands, 290–291
    modems, 289–290
    repeaters, 293–294
    spread spectrum, 291–293
    topologies, 294
    unlicensed bands, 291
  satellite
    basic satellite technology, 297–298
    communication bands, 299
    satellite orbits, 298
  telephone
    analog leased lines and topology, 287
    dial-up line topology, 287–288
    digital phone services and topology, 288
Teleoperated mining
  benefits, 855
  evaluation
    vs. conventional mine life, 855
    grinding and flotation, 856
    integrated PCS, 855–856
    simulation model, 855
  teleremote operation chair, 854, 855
Telephone telemetry
  analog leased line, 287
  dial-up line and topology
    disadvantage, 288
    peer-to-peer, 288
    point-to-multipoint/point-to-point, 288
    regular voice phone service, 287
  digital phone services and topology
    asymmetrical digital subscriber line, 288
    DDS and frame relay, 288
    point-to-point/point-to-multipoint, 288
  telegraph, electric technology, 287
Telnet, *see* TErminaL NETwork
Temperature sensor
  calibration, 911–912
TErminaL NETwork (Telnet), 489
Tests
  generalized likelihood ratio, 373
  global, 371–372
  linear combination, nodes, 372
  MT, 372–373
  nodal, 372
  principal component, 373
Testware, 387
TFTP, *see* Trivial File Transfer Protocol
Thermal power plant, SCADA system
  advantages, 930
  air–gas circuit, 938
  buses and servers, 936–937
  monitoring and control strategy
    architecture, 933–934
    central rack and expansion rack structure, 933
    CET Sud Timisoara, 932
    drawbacks, 931–932
    electric ring networks PB and TB, 933
    requirements, 932
  PCS7 alarm system, 938
  programmable logic controls (PLCs), 930, 931
  remote actions and uninterrupted monitoring, 931, 937
  software technologies, 930
  supervisory control, 930
  system implementation
    PCS7 and software configuration, 934–936
    plant bus (PB) and hardware configurations, 934
  world energy trends, 931
Thermocouples, 339–340
Thermo-optic (TO), 537
Thermophysical
  control, 781–782
  energy, 781–782
  properties, 781–782

Third party packages
  control, 876
  PLC, 876
  vendor, 876
Thixoforming
  automation, 794–795
  Billet model, 782–785
  casting/ingots and hot rolled operation, 781
  fuzzy logic control, 789–793
  heating process, 785–786
  online estimation and control, 786–789
  problem, definition, 781
  thermophysical and energy-based control, 781–782
Threat levels, 685–686
Threats
  data breach, 509
  deliberate, 888–889
  inadvertent, 888
  pharming, 510
  phishing, 510
  SQL injection, 510
Threshold reliability, 78
Time constant, 422–424, 426–428, 430, 432, 434, 436
Time division multiple access (TDMA) principle, 296, 579–580, 638
Timer
  off timer, 96, 97
  on timer, 96, 97
  types, 95
Time series analysis, 234
Time stamping, 806
Time-varying MFA controller, 421, 424, 425, 428
Timing control, 336
Tip speed ratio (TSR), 941
TO, *see* Thermo-optic
Topologies
  bus, 51
  mesh, 51
  point-to-multi point
    analog leased lines, 287
    cellular, 297
    dial-up, 288
    digital phone services, 288
    radio, 294
    satellite networks, 299
    telementry, 285
  point-to-point
    analog leased lines, 287
    cellular, 297
    dial-up, 288
    digital phone service, 288
    radio, 294
    satellite network, 299
    telemetry, 285
  ring, 51
  star, 51
  tree, 51
Traffic engineering, 562, 563
Transducer electronic data sheet (TEDS), 132, 133
Transfer function, 314, 316, 317, 322, 323
Transfer system design
  AGV, 398–399
  determination, items, 399
  items evaluation, 398–399
  material flows connection and types, 398
  motors
    production, 398
    structures, 398, 399
  simulation model, 398, 399
Transform
  Fourier, 316–317, 325
  Laplace, 316, 317
Transistor, 318
Transistor-transistor logic (TTL), 336–337
Transmission Control Protocol (TCP), 485, 489
  socket, 477, 478
Transmission Control Protocol/Internet Protocol (TCP/IP)
  architecture, 485
  suite
    BOOTP, 488
    DHCP, HTTP and ICMP, 488–489
    FTP, 489
    IGMP, 489
    MTA and web-based mail, 490
    protocols, 488
    SNMP, ARP and RARP, 490
    Telnet, e-mail and UA, 490
    TFTP, 489
    UDP, TCP and SCTP, 489
Transmission errors
  character, 585
  checksum, 585
  cyclic redundancy, 585
  frame check, 585
  performance indicator, 585
Transmission medium
  cabling, 49
  coaxial cable, 50
  fiber optic cables, 50
  shielded twisted pair (STP), 50
  twisted pair, 50
  unshielded twisted pair (UTP), 50
  wireless transmission, 50
Transport layer, 54, 469
Trends, 106, 109, 115
  agility, 815–816
  communications, 817–819
  networks
    application layer protocol, 816
    characteristics, 817–818
    communication, 817
    converged Ethernet, 819
    EtherCAT and PowerLink, 819
    multi-network plant architecture, traditional, 818
    SafetyBusP, 816
  safety
    operation modes, 816
    programmable controllers, 816
    robots, 816–817
  sensors
    automotive plants, 818
    traditional wiring, 817
    types, 817
    wiring, industrial communication network, 817, 818
  signal
    communication modules, 817
    dual channel, 816
    safety, 816
Trends in calibrations
  electronic, 146–147
  intelligent, 146, 147
  self calibrations, 146, 147
  soft, 146, 147
Trends in safety systems
  flexibility, 728–729
  focus, 727
  integration, 729, 732
  scalability, 728–729
Triple modular redundant
  duplex system, 718–719
Trivial File Transfer Protocol (TFTP), 489
Trouble shooting, 596
Trunking, 290
Truth table, 309
Truth values, 270–271
TTL, *see* Transistor-transistor logic
Tunable wavelength converters (TWCs), 560, 561
Tuning
  auto, 251–252
  closed loop, 245–248, 251
  data, 236–237
  open loop, 245–247
  parameter, 233
  pre-tune, 251–252
  self, 251–252
TWCs, *see* Tunable wavelength converters
Types of audit
  control system, 703
  databases, 702
  ERP, 703
  field devices, 702–703
  HMI, 703
  network components, 703
  user accounts, 703
  workstations, 703
Types of VPNs
  client based, 518
  remote access, 518
  site to site, 519
  SSL based, 518

U

UA, *see* User agent
UART, *see* Universal Asynchronous Receiver Transmitter
UBET, *see* Unbiased estimation
UCMM, *see* Unconnected message manager
UDP, *see* User Datagram Protocol
UHF bands, 291
Ultrahigh frequency (UHF) bands, 291
Unbiased estimation (UBET), 374
Uncertainties, 374
  deficiency, 142
  type A/B evaluations, 142
  "user calibration", 141
Unconnected message manager (UCMM), 641–642
Underground electric
  control centre, 838
  high voltage switch, 838

    maintenance, 839
    power control, 838
    substation, 838–839
Underground mining
    automation systems, 849
    high capacity cellular network, 850
    positioning systems, 850
    radio systems, 849
    telemining, 849–850
Underwriters Laboratories (UL), 707, 713
Unicast communications, 492
Unified contention resolution, 561
Uniform resource locators (URLs), 487
Unit batch
    idle state, 185
    modes, 185
    states, 185
    transition, 185
Universal Asynchronous Receiver Transmitter (UART), 585
Universal datagram protocol (UDP), 275
Universal serial bus (USB), 354
Unlicensed bands, 291
Unreliability
    definition, 737
    failure modes, 738
    life time interval, 739
Upgrading plants, *see* Auditing plants
Upper explosive limit (UEL), 708
URLs, *see* Uniform resource locators
User agent (UA), 490
User Datagram Protocol (UDP), 489
Using standards, 155

V

Valve travel, 207
Variability, 230–231
Variable classification, *see* Five-unit three-node system
Variables
    key, 73–76, 78, 79, 81, 82, 85
    measured, 73, 74, 76, 77, 80–82
Variance and covariance matrix
    flow rate estimators, 367
    global test, 371
    steady-state data reconciliation
        direct and indirect method, 370
        values, 369
VCO, *see* Voltage controlled oscillator
Verification and validation (V&V), 406, 411–413
Version DPV1
    architecture, 619–620
    extended device descriptions (EDDs), 622
    general station data (GSD), 622
    media access, 620–622
    network configuration, 622–623
Very high frequency (VHF), 290, 291
VHF, *see* Very high frequency
VI, *see* Virtual instrumentation
Virtual factory model, 391
Virtual instrumentation (VI), 356–358, 426, 428–431
Virtual plants
    consumer behavior and intense competition, 391
    manufacturing system
        emulation, implementation phase, 401–404
        engineering process, 391–393
        simulation, design phase, 393–401
    product data and life cycle, 404
    simulation technologies, 391
Virtual private networks (VPNs), 278, 475
    characteristics
        information security, 517–518
        operations, 517
    LAN, 517
    managing, 523
    protocols
        AH, 521
        ESP, 521
        IKE, 521
        IPsec, 519–521
    tunnels
        data encapsulation, 519
        site-to-site, 519, 520
    types, 518
Virtual reality (VR)
    control room, 409–411
    definition, 406
    design, 412
    technology, 412, 413
    testing, 407, 413
    tools
        control room, 409–411
        3D objects, 407–409
        software requirements, design and testing, 407
        time and money consumption, 413
        V&Vdesign, 411–413
Vnet/IP®, 349
Voice over Internet Protocol (VoIP), 487, 493
VoIP, *see* Voice over Internet Protocol
Voltage controlled oscillator (VCO), 321
Voltage to current converter, 320
Voting system
    calibration drift, 743
    control strategy, 744
    median signal select, 744
    proof testing, 743
    sensor/logic/effecter chain, 743
VPN, *see* Virtual private networks
VR, *see* Virtual reality
VR software
    design and testing, 407
VR testing, 407, 413
V&V, *see* Verification and validation
VXI bus, 351

W

Wakes, 942, 945, 946
WAN, *see* Wide area network
Wastewater liftstation, 858
Wastewater treatment, 417, 424
Wastewater treatment plant, 858
Water treatment
    plant, 858
    telemetry, 858–859
Water treatment plants, telemetry control
    application
        DeviceNet system, 858
        profibus, 858
    controllers
        distributed control, 868–869
        fiber optic communications and networks, 869
        industrial Ethernet and TCP/IP based systems, 869
        IT *vs.* networks, 869
        PLC, 868
        protocol bridges, 869
    network routing
        affecting issues, 864
        connectivity, 864
        decisions, 865–866
        domain and non-routers, 865
        firmware, old version, 866
        interference, 865
        misconfigured packets, 866
        radios, misconfigured, 866
        repeater latency, 865
        UtiliNet radio, 864
    organizational recommendations
        diagnostics, 867–868
        operational, 868
        performance metrics, 868
        radio communications network maintenance, 868
        standards, 867
    packet radio
        AMR system, 859
        communications networks, 859
        DWS-808 backbone, 861
        DWS-805 meter reading, 860–861
        head-end, 860
        location, 859–860
        project applications, UtiliNet network, 860
        UtiliNet packet, 859
    radio network issues
        concerns, 863–864
        ownership, 866–867
        PC-713 communication, 863
        WSD owner, 867
    SCADA system
        field sites, 862
        radio traffic, 862–863
    wastewater liftstations, 858
    well fields, reservoirs, tanks and pump stations, 859
Water well fields
    pump stations, 859
    reservoirs, 859
    tanks, 859
Waveband grouping, 549
Waveband switching (WBS)
    grouping, 549
    MC-OXC, 548–549
    OXC, 547–548
    single input and output port, 548
    TDM and grooming
        opto-electrical switch architecture, 549
        physical transmission impairment, 550

Wavelength assignment, 555
Wavelength conversion
  FDL, 560, 561
  MZI, 543
  SOA, 543
  TWC, 560, 561
Wavelength division multiplexing (WDM)
  OBS network, 553
  optical add-drop multiplexer, 547
  optical network technology, 561
  PSR node, 551
  reconfigurable, 552
  single/multiple wavelength channel, 546
WBS, *see* Waveband switching
WDM, *see* Wavelength division multiplexing
Web
  control, 894–896
  monitoring, 894–896
  security, 894–895
  security mechanism, 895–896
  security token, 895
Web documents
  active, 487
  dynamic, 487
  static, 487
Weibull distribution, 941
Weighting, 271
Weighting factors, 418, 420
Weight on bit, 435
WEP, *see* Wired equivalent privacy
Wheatstone bridge circuit, 340
White box, 417, 436
Wide area network (WAN), 288
  applications
    components, 474
    extranet and internet, 475
  corporations/organizations, 474
  described, 467
  packet switching technology, 473
  subnet role, 474
  technologies, 475–476
Wi-Fi, 355
  2.4–2.4835 GHz band, 292
  IEEE 802 wireless technology, 284
  routers, 291
WiMAX, *see* Worldwide interoperability for microwave access
Wind
  communication profile, 886
  information, 884–885
  information exchange, 885–886
  model, 884–886
  plants, 884–887
  power, 884–887
Wind energy
  efficiency, 940–942, 946
  farms
    balance of plant, 944
    communications infrastructure, 945
    control, 945–946
    forecasting, 947
    lifecycles, contracts and key performance index, 946
    meteorological masts, 944
    operations, 947
    portfolios, 946–947
    substations and grid interfaces, 944–945
  industry size and global potential, 943
  power curve, 941, 942, 946
  principles, 940–943
  SCADA systems, 947–949
  turbines
    controllers, 544
    design, 943
    farm arrangement, 3-blade turbines, 943
  wind turbines, 943–944
Wind farms
  balance of plant, 944
  communications
    copper systems, 945
    Ethernet, 945
    protocols, 947–948
    SCADA systems, 945
    serial radios, 945
  condition monitoring, 948–949
  contracts, 946, 947
  control issues
    shadow flicker, 946
    site layout, 945
    sound, 945–946
    threat, birds and bats, 946
  data maintenance, 947, 948
  forecasting, 947
  key performance index (KPIs), 946, 947
  meteorological masts, 944
  operations, 940, 947
  portfolios, 940, 946–947, 949
  project life cycle, 940, 946
  protocols, 944, 945, 947–948
  SCADA, 945–949
  substations and grid interfaces
    remote terminal unit (RTU), 945
    revenue meters and transformer, 944
Wind power industry
  global, 940, 943
  size, 940, 943
  turbines, 940–949
Wind rose, 943
Wind turbine, 940–949
WinSit software, 789
Wired equivalent privacy (WEP), 482
Wireless
  Foundation Fieldbus, 608–611
  HART, 609–610
  ISA100, 609–610
  standards, ISA100 *vs.* WirelessharHART, 609–610
WirelessHART, 344, 596
  field devices, 344
  gateways, 344
  network manager, 344
Wireless local area network (WLAN)
  advantages and disadvantages, 479–480
  applications, 478
  configurations, 480
  OFDM technology, 478
  security
    issues, 481–482
    standardization, 482
  standardization, 480
  standard protocol, 480–481
Wireless network components
  base station, 478–479
  host, 478
  link, 478
Wireless networking, 355
Wireless networks
  address security and performance issues, 281
  advantages and disadvantages, 479–480
  attributes, interface standards, 49
  components, 478–479
  configurations, 480
  ISA100.11a standard, 49
  manufacturing plants, 281
  modems and WLAN, 478
  "motes", 47
  standardization, 480
  wireless devices, 36
  wirelessHART, 9, 31, 33, 37, 47
Wireless network security
  attacks, 482
  unauthorized access, 481–482
Wireless networks WiFi, 355
Wireless technology types
  CDPD, 481
  GPRS, 481
  GSM, 481
  LMDS, 481
  UMTS, 481
  Wi-Fi, 481
  WiMAX, 481
WLAN, *see* Wireless local area network
Work
  control, 751
    craft, 752
    function, 751
    priorities, 751–752
  order, 752
Work cells
  control structure, 164–165
  in-house software development, 165
  MMS, 166
  programming, 164–166
  software, enabler, 165–166
Workstations
  local stations, 106–107
  master station (MS), 106–107
World energy trends
  demand, fuel, 931
  green fuels, 931
  low carbon emission fuels, 931
  thermal power plant, Timisoara, 931
WorldFIP, 347–349
  application, 664
  communication profile, 663
  data link
    periodic variable exchange, 664
    scanning table and variable production cycles, 664
    services, 664
  physical, 663–664
  transport, 663

Worldwide interoperability for microwave access (WiMAX), 481
  2.4–2.4835 GHz band, 292
World Wide Web (WWW)
  described, 487
  HTML, 487
  HTTP, 487
  semantic web, 487
  URL, 487
  XML, 487
WWW, *see* World Wide Web

X

X.25 (packet switching protocol standard), 473
XML, *see* Extended Mark-Up Language

Y

Yagi antenna
  radio repeater, 293
  radio topology, 294

Z

ZigBee, 355
  2.4–2.4835 GHz band, 292
  IEEE 802 wireless technology, 284
Zone
  class I, 708
  class II, III, 709
  NEC division, 708